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Space Shuttle System

PHASE B STUDY FINAL REPORT

Part I
Summary

DETAIL MASS PROPERTIES REPORT

SUBMITTED UNDER
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INTRODUCTION

1.0 General - This Detailed Mass Properties Report is submitted by the McDonnell Douglas/Martin Marietta Space Shuttle Team in compliance with the requirements of Data Requirements Description No. SE005M under contract number NAS 8-26016. The reporting period covered is from 17 June 1970 to 15 June 1971. This submittal contains the following elements:

Element		Author
Report E0377-	Detailed Mass Properties Report	
Part 1 -	Summary (this volume)	J. Windham (MDAC)
Part 2 -	Orbiter Details	R. Fessenden (MDAC)
Part 3 -	Booster Details	R. Dobson(MDAC)/C. Kline(Martin)
Report E0403-	Summary Mass Properties Report (Final Baseline Design)	J. Windham (MDAC)

In addition to the above authors, major contributions were made to Report E0377 - Part I by R. Ridenour, to Part II by W. Fogarty, J. Garrison, B. Grob and W. Gustin, to Part III by W. Georlitz, L. Otter and P. Scott (All of MDAC) and W. Ahl and G. Graves of Martin. The report format was monitored and coordinated by R. Mason and E. Phelps of NASA-MSC and J. Daniels and R. Scott of NASA-MSFC.

Report E0377-Part 1 contains summary data for the Orbiter, Booster and combined vehicles which is comparable in depth to that presented in the regular monthly mass properties status reports. In addition, appendicies are included which contain detail weight summaries, comparisons of Phase B Shuttle weights to historical data and Design Mass Properties. Report E0377-Parts II and III contain detail weight substantiation data for the Orbiter and Booster respectively.

Throughout Report E0377 data is presented for the Design Mission (65K payload, Easterly launch from ETR) except where specifically noted otherwise. Supplemental

data for the Resupply (25K payload plus Orbiter Airbreathing Engines, 55 degree inclination from ETR) and Polar (40K payload from ETR) missions is presented in Appendix B of Part I.

In developing the substantiating data for the Detailed Mass Properties report a number of desirable changes were not incorporated because of inadequate time. These are listed in this report as pending changes.

Report E0403 is a summary report, comparable in depth to a normal monthly status report, which picks up these pending changes and presents our final design baseline. This "final design baseline" has the same size Orbiter and Booster as the "analysis vehicle" which has been used as the basis for the Detailed Mass Properties report and differs only as indicated in the pending change list.

1.1 Analysis Vehicle Results - Orbiter and Booster weights are summarized in Table 1-1 and the percentage of each subsystem weight that is estimated or calculated is indicated. For the purpose of this Phase B report the normal definitions of estimated and calculated have been modified as follows:

Calculated Weight = based on Phase B drawings and design analyses and vendor quotes (normally "calculated weights" are based on released drawings)

Estimated Weight = based on empirical correlations or other comparisons to past hardware designs

In a number of instances, items that we have classified as estimated could probably equally well have been called calculated. Propulsion system valves, for example, were actually sized based on an analysis of the propulsion system but valve weights were obtained by comparisons to actual valve weights for past designs of similar size and pressure. The same is true of the bellows assemblies where a detailed dynamic stress analysis was not within the scope of the Phase B design effort.

TABLE 1-1 - WEIGHT SUMMARY (LAUNCH CONDITION) (EASTERLY MISSION)

CONFIGURATION	CANARD BOOSTER	DELTA ORBITER	BY		DATE	

CODE	SYSTEM	ITEM OR MODULE							
		BOOSTER	EST	CAL	ACT	ORBITER	EST	CAL	ACT
1	WING GROUP	57954	9%	91%		31587	17%	83%	
2	TAIL GROUP	19214	12%	88%		5104	11%	89%	
3	BODY GROUP	148599	8%	92%		55500	18%	82%	
4	INDUCED ENVIR PROTECTION	84807	5%	95%		32847	9%	91%	
5	LANDING, RECOVERY, DOCKING	25885	42%	58%		10551	100%	0%	
6	PROPULSION-ASCENT	123320	16%	84%		26637	20%	80%	
7	PROPULSION-CRUISE	37053	6%	94%		574	54%	46%	
8	PROPULSION-AUXILIARY	5396	8%	92%		11877	33%	67%	
9	PRIME POWER	3582	11%	89%		2272	100%	0%	
10	ELECT CONVER & DISTR	1818	12%	88%		1303	100%	0%	
11	HYDRA CONVER & DISTR	7282	77%	23%		2760	70%	30%	
12	SURFACE CONTROLS	11320	19%	81%		4901	97%	3%	
13	AVIONICS	4941	45%	55%		4588	45%	55%	
14	ENVIRONMENTAL CONTROL	2058	52%	48%		7849	32%	68%	
15	PERSONNEL PROVISIONS	288	100%	0%		430	63%	37%	
16	RANGE SAFETY & ABORT	0				0			
17	BALLAST	0				0			
18	GROWTH/UNCERTAINTY	42009	100%	0%		25363	100%	0%	
19									
	SUBTOTAL (DRY WEIGHT)	(575526)	(19%)	(81%)		(224143)	(24%)	(76%)	
20	PERSONNEL	522	0%	100%		626	63%	37%	
21	CARGO					65000			
22	ORDNANCE					0			
23	RESIDUAL FLUIDS	14707	0%	100%		4001	0%	100%	
24									
	SUBTOTAL (INERT WEIGHT)	(590755)	(19%	(81%)		(293770)	(18%)	(82%)	
25	RESERVE FLUIDS	34245	0%	100%		13118	0%	100%	
26	IN FLIGHT LOSSES	22847	0%	100%		9788	0%	100%	
27	PROPELLANT-ASCENT	3038600	0%	100%		526257	0%	100%	
28	PROPELLANT-CRUISE	97000	0%	100%		0	0%	100%	
29	PROPELLANT-MANEUV/ACS	1212	0%	100%		17510	0%	100%	
30									
	TOTAL (GROSS-WEIGHT) LB	(3784659)	(3%)	(97%)		(860443)	(6%)	(94%)	

DESIGNATIONS:

CLASS OF WEIGHT
EST - PERCENT ESTIMATED WEIGHT
CAL - PERCENT CALCULATED WEIGHT
ACT - PERCENT ACTUAL WEIGHT

NOTES & SKETCHES:

(1) Gross Liftoff Wt = 4645102 lb.
(2) Weights shown are for the "Analysis Vehicle". Orbiter weights differ from those presented in Report E0403 for the "Final Design Baseline" by the pending changes shown in Table 2-2.

Our primary approach throughout the weight substantiation sections has been to place the emphasis on in-depth point design analyses. In Appendix C, the results of these detailed analyses are compared to weights from past hardware designs to show that our current design is realistic.

Table 1-2 is a summary of Orbiter pending changes for the analysis vehicle. There are no pending changes for the Booster and the "analysis" Booster is therefore identical to that shown in Report E0403 for the "final design baseline".

In order to provide a basis for the Phase B detailed design analyses, the Orbiter and Booster sizes were frozen at the time of the 8th month data dump which is reported in the 15 March 1971 Detailed Mass Properties Report. With this frozen vehicle size our reporting approach has been to hold the required payload for each mission and to vary the Orbiter and Booster growth/uncertainty allowances as necessary to meet performance requirements. Any change in vehicle weight, propellant loading or performance as the design matured has been reflected as a change in the allowable growth/uncertainty. The target value for this allowance is 10 percent of the vehicle dry weight less growth/uncertainty, ascent engine weight and cruise system engine weight. The final values of growth/uncertainty are derived in Table 1-3. These values exceed the 10 percent target for all missions.

1.2 Summary of Design Characteristics and Requirements - Key design characteristics are summarized in Table 1-4.

TABLE 1-2 - PENDING MASS PROPERTIES CHANGE ANALYSIS

CONFIGURATION: DELTA ORBITER | BY: | DATE:

ITEM	WEIGHT SUMMARY ITEM EFFECTED	Δ WT. LB.	C.G. IN.	REMARKS
Purge Liner to Purge Ducts	14	-503		No Booster Pending Changes. Booster "Analysis Vehicle" same as "Final Design Baseline".
Revised TPS	4	-4061		
Inconel & Rene to Hastelloy				
Add Base Vent Valve				
Add Low Emittance Coatings				
Metallic L.E. Wing and Tail				
Interference Heating				
Remove Ground Cooling				
Wing Leading Edge Mat'l Chngs	1	-1111		
Tail Leading Edge Mat'l Chngs	2	- 72		
Windshield Covers	4	+150		
New Temperature (Structure)	3	+848		
Flared Rudder	2	+2100		
Beavertail	3	+643		
Titanium Tail (was Rene)	2	-2511		
Larger Cabin	3	+160		
Elevon Area & Loads Increase	1	+638		
Wing Changes	1	+130		
Segmented Payload Door	3	+113		
Windshield Design	3	+213		
EVA Observation	3	+ 87		
Separate LOX Vent	6	-320		
Change Vent Line Size	6	+2499		
Stainless Steel to Alum OMS Lines	8	-152		
Add Fillet	3	+100		
Gimbal RL-10's	8	+250		
Entry Purge	14	+330		
Final Loads				
Tail	2	+838		
Interstage	3	+550		
Fuselage	3	+700		
Aft Fuselage	3	+915		
		+ (2534)		

TABLE 1-3 CURRENT GROWTH/UNCERTAINTY PERCENTAGE DERIVATION

ITEM	EASTERLY		RESUPPLY		POLAR	
	BOOSTER	ORBITER	BOOSTER	ORBITER	BOOSTER	ORBITER
Gross Weight (Lb)	3838220	860443	3834125	845989	3809114	853408
Start Propellants (Lb)	53561	1962	53561	1962	53561	1962
Weight at Start of Burn (Lb)	3784659	858481	3780564	844027	3755553	851446
Usable Propellant Less 1% Flight Perf. Reserve(Lb)	3038600	526257	3038600	526434	3038600	548927
Burnout Weight (Lb)	746059	332224	741964	317593	716953	302519
Other Expendable Fluids	155304	38454	148304	52565	126304	36026
Inert Weight (Lb)	590755	293770	593660	265028	590649	266493
Cargo (Lb)*	0	65000	0	25000	0	40000
Personnel & Residual Fluids (Lb)	15229	4627	15089	4831	14649	4627
Dry Weight (Lb)	575526	224143	578571	235197	576000	221866
Ascent Engines (Lb)	89940	17620	89940	17620	89940	17620
Cruise Engines (Lb)	26140	0	26140	10620	26140	0
Current Growth/Uncert(Lb)	42009	25363	45054	21718	42483	23086
Base Wt for Growth/Uncer. Calc. (Lb)	417437	181160	417437	185239	417437	181160
Growth/Uncertainty - Percent	10.06	14.00	10.79	11.72	10.18	12.74
Total System Growth/Uncert.-%	12.94		11.49		12.12	
Pending Chngs Effect on Growth/Uncer(Lb)	0	-2534	0	-2534	0	-2534
Pending Chngs Effect on Growth/Uncer-%	0	-1.57	0	-1.50	0	-1.55
Growth/Uncert. with Pending Chngs - %	10.06	12.43	10.79	10.22	10.18	11.19
Total System Growth/Uncert with Pending Chngs-%	11.82		10.37		10.96	

TABLE 1-4 SHUTTLE DESIGN CHARACTERISTICS
(Analysis Vehicle)

	Orbiter	Booster
Geometric Data		
Length (Base to Nose) - Ft	160.3	242.5
Wing Span - Ft	107.5	146.
Wing Area (Theoretical) - Sq Ft	5543.	6015.6
Wing Area (Exposed) - Sq Ft	3557.	4068.
Vehicle Planform Area - Sq Ft	7675	13015.
Body Wetted Area - Sq Ft	14022	26121
Vehicle Wetted Area - Sq Ft	22819	40507
Body Outer Moldline Volume - Cu Ft	76095	211783
Vehicle Outer Moldline Volume - Cu.Ft	91310	231575
Ascent Propellant Tank Volume - Cu Ft	25398	146470.
Reference Drawing Number	255BJ00050 Rev. F	256-20-001 Rev. A
Aerodynamic Data		
Entry Angle of Attack - Deg	30	60
Hypersonic L/D Max. (Trimmed)	1.48 @ 30°	0.53
Angle of Attack (Subsonic L/D Max) - Deg	8.2	9.5
Subsonic L/D Max (Trimmed)	6.7	7.92
Cruise L/D (Average)	N/A	~7
Propulsion		
Ascent Engine Thrust - Lb		
Sea Level	DNA	550000
Vacuum	632000	604000
Ascent Engine Vacuum Specific Impulse - Sec	459*	439*
Ascent Engine Expansion Ratio	85/150:1	35:1
Number of Ascent Engines	2	12
Number of Cruise Engines	4 **	10

* Minimum I_{sp} (456,436) used for tank sizing.
** Not used for Easterly and Polar Missions.
*** OMS tank fillup and parallel burn of 2 RL-10's used for Polar mission.

NASA has expressed space shuttle requirements in the following documents:

Space Shuttle Program Requirements Document, Level I, 1 Jul 70, Hq NASA

Space Shuttle System Level II Requirements, 15 Jun 70, MSFC/MSC

Space Shuttle Orbiter Requirements Document, Level II, 15 Jul 70, MSC

Detailed final requirements are contained in the Space Shuttle Requirements Document (complied by MDAC). Some of the key requirements that effect vehicle weight are summarized in Table 1-5.

TABLE 1-5 REQUIREMENTS SUMMARY

REUSABLE TWO STAGE.
CARGO BAY SIZED TO HAVE CLEAR VOLUME OF 15' DIA. BY 60' LONG.
IOC BASELINE IS MID 1979.
NO FIXED GLOW.
THE DESIGN MISSION SHALL BE A 100 NM DUE EAST CIRCULAR ORBIT. THE DESIGN MISSION INSERTION ORBIT SHALL BE 50 x 100 NM AND FOR PURPOSES OF PERFORMANCE COMPARISON CALCULATIONS THE VEHICLES SHALL BE CONSIDERED TO BE LAUNCHED FROM A LATITUDE OF 28.5 DEGREES NORTH. THE REFERENCE MISSIONS OF MAJOR INTEREST ARE: (1) 100 NM SOUTH POLAR CIRCULAR ORBIT; (2) 270 NM AT 55 INCLINATION.
ORBITER SHALL HAVE A NOMINAL HYPERSONIC AERODYNAMIC CROSSRANGE CAPABILITY TO RETURN TO THE LAUNCH SITE.
VEHICLE PAYLOAD IS BASELINED TO BE 65,000 POUNDS INTO THE DUE EAST 100 NM CIRCULAR ORBIT WITH THE AIRBREATHING ENGINES REMOVED FROM THE ORBITER. THE WEIGHT OF PASSENGERS AND REMOVABLE PROVISIONS FOR PASSENGERS SHALL BE CHARGED TO THE PAYLOAD. THE ORBITER SHALL HAVE THE CAPABILITY OF LANDING 40,000 POUNDS OF PAYLOAD WITH NOMINAL WIND AND LOAD FACTORS (AIRBREATHING ENGINES REMOVED) AND LARGER PAYLOADS WITH REDUCED STRUCTURAL SAFETY FACTORS. MISSION DURATION 7 DAYS SELF SUSTAINING.
OPERABLE WITH CARGO RANGE FROM ZERO TO MAXIMUM.
1,500 FPS ON-ORBIT ΔV CAPABILITY FOR THE 270 NM AT 55 DEGREES INCLINATION REFERENCE MISSION, THE TANKS SHALL BE SIZED TO PROVIDE 2000 FPS DELTA V CAPABILITY.
BOOSTER AND ORBITER BASELINED TO HAVE GO-AROUND CAPABILITY.
SHIRTSLEEVE ENVIRONMENT COMPATIBLE WITH SPACE STATION/BASE.
BOOSTER CAPABLE OF FLYBACK TO LAUNCH SITE.
BOOSTER AND ORBITER CAPABLE OF FERRY FLIGHTS.
MATED VERTICAL TAKEOFF - INDIVIDUAL HORIZONTAL LANDING.
A COMMUNICATION SATELLITE SYSTEM ASSUMED AVAILABLE (MDAC SYSTEM CAN OPERATE WITHOUT IT INITIALLY).
LAUNCH RATES WILL VARY FROM 25 TO 75/YEAR. (445 in 10 YRS)
ALL AZIMUTH LAUNCH.
SAFE MISSION TERMINATION CAPABILITY. RAPID CREW AND PASSENGER EGRESS PRIOR TO LIFT-OFF AND INTACT ABORT AFTER LIFT-OFF. THE ORBITER SHALL BE CAPABLE OF A ONCE AROUND TRAJECTORY WITH A ONE ENGINE OUT CONDITION AT AND/OR AFTER BOOSTER ORBITER SEPARATION FOR THE DESIGN AND REFERENCE MISSION.
550K LB SEA LEVEL THRUST MAIN ENGINES.
10 YEAR LIFE AFTER IOC.
JP WILL BE BASELINED AS FUEL FOR ALL AIRBREATHING ENGINES. THE AIRBREATHING ENGINES SHALL BE CAPABLE OF BEING REMOVED FROM THE ORBITER WITH MINIMUM SCAR WEIGHT. THE ORBITER SHALL BE CAPABLE OF FLIGHT WITH OR WITHOUT THE AIRBREATHING ENGINES INSTALLED.

TABLE 1-5 REQUIREMENTS SUMMARY (CONT.)

ALL SUBSYSTEMS (EXCEPT STRUCTURE AND PRESSURE VESSELS) FAIL OPS/FAIL SAFE. ELECTRONICS FAIL OPS/FAIL OPS/FAIL SAFE. MAIN ENGINE - FAIL SAFE. MAIN ENGINE ELECTRONICS - FAIL OPS/FAIL SAFE.
TWO WEEK MAXIMUM GROUND TURN AROUND.
LAUNCH TRAJECTORY LOAD FACTORS SHALL NOT EXCEED 3G'S AND ENTRY TRAJECTORIES SHALL NOT EXCEED 3G'S FOR THE ORBITER.
TWO MAN FLIGHT CREW EACH VEHICLE.
NO SUBSONIC IN-FLIGHT REFUELING.
SERIES BURNING OF BOOSTER AND ORBITER MAIN PROPULSION.
WITH SINGLE MAIN ENGINE OUT: IN BOOSTER-NOMINAL MISSION, IN ORBITER-SAFE ABORT.
DESIGN FOR COMMONALITY.
NO PROPELLANT CROSSFEED.
JETTISON OR DEPLETE CRYOGENIC PROPELLANTS PRIOR TO LANDING.
10,000 FT RUNWAYS.
INTERNAL, SEALABLE TUNNEL FROM PAYLOAD COMPARTMENT TO CARGO BAY.
MINIMUM SINGLE ENGINE I_{SP} FOR SIZING, NOMINAL I_{SP} FOR PERFORMANCE.
1 PERCENT OF TOTAL ΔV CARRIED IN ORBITER FOR FLIGHT PERFORMANCE RESERVE.

1.3 Minimum I_{SP} Sizing - The weights shown in Table 1-1 and throughout this report reflect vehicle and main propellant tanks volumes that are "oversized" i.e., will hold more propellant than the nominal loadings shown. Main propellant tanks are sized for the Polar Mission with minimum vacuum I_{SP}'s of 456 for the Orbiter and 436 for the Booster. Nominal propellant loads were then obtained by changing to the nominal vacuum I_{SP}'s of 459 and 439 for the Orbiter and Booster and off-loading propellant until the same performance (Payload and Growth/Uncertainty Allowance) was obtained as for the minimum I_{SP} case. These nominal propellant loadings which were derived for the Polar mission were then used for Easterly and Resupply missions. The performance values quoted for the Easterly and Resupply missions are based on these nominal loadings.

Propellant loads and burnout weights for minimum and nominal I_{SP} cases for each mission are summarized in Table 1-6. In comparing propellant loads from Table 1-1 for the Easterly mission to Polar and Resupply mission data in Appendix B it does not appear that the same Orbiter nominal propellant load has been used for all missions. This is because of differences in reserve propellant due to the differences in total ΔV between missions and to the 22368 lb of OMS fill-up propellant for the Polar mission which is grouped with the ascent propellant in the weight summary. If the OMS fill-up increment is removed on the Polar mission, and if flight performance reserves and ascent propellant are combined, then the same total orbiter ascent propellant load is obtained for each mission.

The ascent tank sizes include volume for a 3 percent ullage space and 1 percent loading tolerance in addition to that required for the maximum propellant loads shown in Table 1-6.

TABLE 1-6 COMPARISON OF NOMINAL AND MINIMUM I_{SP} PROPELLANT LOADINGS

ITEM	MINIMUM I_{SP}	NOMINAL I_{SP}	WEIGHT OFFLOADED
Polar Mission			
Orbiter			
Nominal Ascent Tank Prop.-Lb	534819	526559	8260
OMS Tank Fill-up Increment - Lb	22368	22368	0
Flight Performance Reserve - Lb	6225	6184	41
Total Usable Ascent Propellant - Lb	(563412)	(555111)	(8301)
Booster			
Total Usable Ascent Propellant - Lb	(3085081)	(3038600)	(46481)
Resupply Mission			
Orbiter			
Nominal Ascent Tank Prop. - Lb	534700	526434	8266
Flight Performance Reserve - Lb	6344	6309	35
Total Usable Ascent Propellant - Lb	(541044)	(532743)	(8301)
Booster			
Total Usable Ascent Propellant - Lb	(3085081)	(3038600)	(46481)
Easterly Mission			
Orbiter			
Nominal Ascent Tank Propellant - Lb	534519	526257	8262
Flight Performance Reserve - Lb	6525	6486	39
Total Usable Ascent Propellant - Lb	(541044)	(532743)	(8301)
Booster			
Total Usable Ascent Propellant - Lb	(3085081)	(3038600)	(46481)

Notes:
(1) Flight Performance Reserve equal to 1% of total ascent ΔV.
(2) Min. I_{SP} = 456 sec for Orbiter, 436 sec for Booster
(3) Nom. I_{SP} = 459 sec for Orbiter, 439 sec for Booster.
(4) 1962 lb of startup propellant is not included in Orbiter usable propellant.
(5) Propellant weights do not include 1% loading allowance.

2.0 WEIGHT CHANGE SUMMARY (PROPOSAL TO PRESENT) - Defining the weight change history during Phase B is complicated by:

(a) A virtually new configuration was adopted following the proposal and first reported in MP-1. This change resulted in a decrease in payload from 36,200 pounds to 13,450 pounds. The Booster was changed from a twin body to a single body canard. The Orbiter was resized, ascent ΔV was increased and the TPS was changed from active to passive.

(b) Additional missions are now considered and are the critical conditions in sizing. Also, the definition of Growth and Payload has been revised several times.

The primary Orbiter and Booster weight changes from MP-1 through MP-10 are summarized below for the 25K, 55° mission.

The primary Orbiter weight changes, exclusive of Payload, Growth/Uncertainty and Usable Ascent Propellants are:

- 17,000 pounds increase in Reserve, Residual and Service fluids
- 9,500 pound increase in changing Ascent Engine from 400K to 550K
- 6,000 pound increase in Auxiliary Propulsion System
- 3,500 pound increase in compartment insulation and purge liner
- 5,500 pound increase from miscellaneous changes including: add Speed Brakes, Increase Payload Provisions, External to Internal ABES and better ascent propulsion system definitions.
- Negligible weight changes in structural system.

The primary Booster weight changes, exclusive of Growth/Uncertainty and Usable Ascent Propellants are:

- 105,000 pound increase in cruise propellants, primarily a change from L.H. to JP-4 and 20,400 pound reduction for G.E. vs P&W engines.

- o 48,400 pound increase in changing from 12 400K to 12 550K ascent engines
- o 44,600 pound increase in TPS due primarily to increasing the protected area from about 55% to 100% of wetted area and to reanalyzed unit weights
- o 22,500 pound increase in resizing tanks to increased propellant requirements
- o 12,600 pound increase for 10 G.E. cruise engines vs 8 P&W engines
- o 10,400 pound increase for increased reentry/landing weights and revised wing loads.
- o 10,600 pound decrease in Reserve, Residual, and Service fluids, primarily due to revised shut-down criteria
- o 17,300 pound increase in revised analysis of subsystems. Major items are Body +16,000 lb., reduced tail area -9,700 lbs., Hydraulic/Surface Controls + 6,200 lbs., add Purge system 3,600 lbs., and miscellaneous of 1,200.

Phase B weight changes are summarized in Table 2.0-1. The weight history of the two primary status indicators, i.e., payload and the growth/uncertainty allowance is discussed in Section 2.1 below. These parameters have been normalized somewhat in order to provide a better picture and at any report time the characteristics are shown for the critical mission at that time. In Section 2.2 a more conventional presentation of weight changes during the program is presented. In Section 2.3, updates of the various weight history charts that have been presented in the monthly reports are shown.

2.1 Weight History of Key Status Indicators (Payload and Growth/Uncertainty Allowance) - Prior to the 3 December status report (MP-5) the growth/uncertainty allowance was held at 10 percent of dry weight and design changes were reflected by changes in payload as shown in the left portion of Figure 2.1-1. The growth/

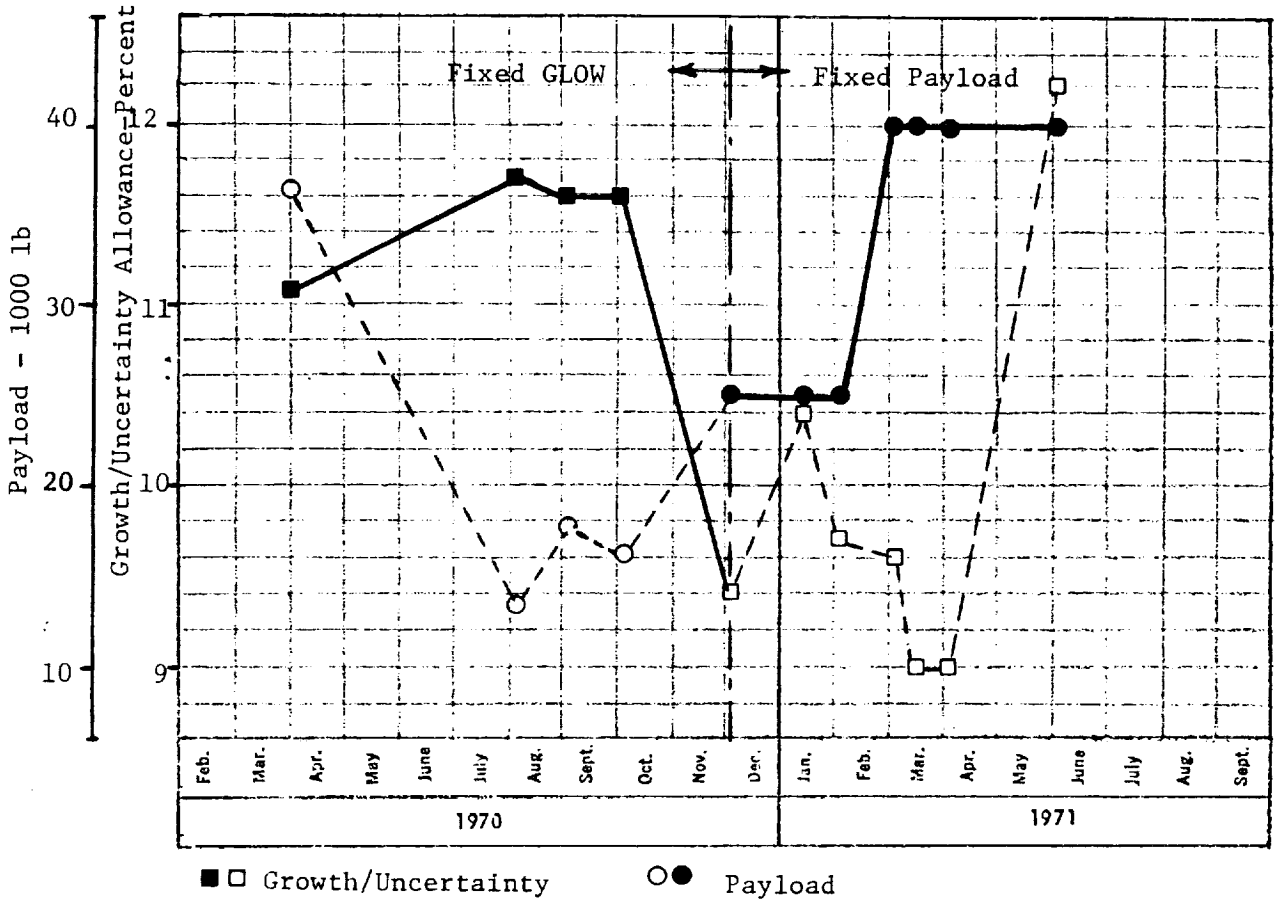
Table 2.0-1

PHASE B SHUTTLE WEIGHT SUMMARY

ORBITER WEIGHT CHANGE SUMMARY				
	MP-1	MP-10	ΔW	% Change
Gross Weight	(685000)	(835402)	(150402)	22%
Ascent Propellant	418948	518242	99294	24%
G.W. less Asc. Prop.	(266052)	(317160)	(51108)	19%
Cruise/Maneuver/ACS	35306	29971	-5335	-15%
Payload	13450	25000	14642	15%
Growth	18516	21608		
Personnel	400	626	226	
Sub-Total	(198380)	(239955)	(41575)	21%
Reserve/Residual/Losses	13221	30269	17048	128%
Dry Wt. Less Growth	(185159)	(209686)	(24527)	13%

BOOSTER WEIGHT CHANGE SUMMARY				
	MP-1	MP-10	ΔW	% Change
Gross Weight	2840111	3752100	(911989)	32%
Ascent Propellant	2361387	3034900	673513	28%
G.W. Less Ascent Prop.	478724	717200	(238476)	50%
Cruise	27395	132000	104605	384%
Residual/Reserve/Losses	51271	43385	-7885	-16%
Growth	36405	24248	-12157	-33%
Dry Weight Less Growth	363653	517567	(153914)	42%

Figure 2.1-1 Payload and Growth/Uncertainty Weight History



uncertainty shown does not plot as a constant 10 percent because it has been adjusted to the current approach of expressing growth/uncertainty as a percent of dry weight less ascent engines, cruise engines and growth/uncertainty. In the 3 December and subsequent status reports payload has been held constant and design changes are reflected by changes in the growth/uncertainty. The change in payload shown between 3 February and 3 March is due to the requirements change requiring consideration of 40K polar and 65K easterly missions in addition to the 25K, 55 degree inclination resupply mission with airbreathing engines. Of these three missions, the 40K polar has been the most severe and is shown for the last four points in Figure 2.1-1. The weight history forms in our last four

status reports, however, have reflected the 65K easterly mission because in the revised requirements this mission is established as the "design" mission.

Some key changes associated with the various status report points indicated in Figure 2.1-1 are summarized below.

3 August 1970 - Changed from twin body booster to single body canard booster and resized delta orbiter. Large reduction in payload was due primarily to 500 ft/sec increase in estimated ΔV required and change from active to passive orbiter TPS.

3 September 1970 - Orbiter resized to optimize staging velocity. Booster resizing pending but not incorporated.

3 December 1970 - Orbiter and booster resized, changed from LH to JP cruise fuel, changed from 3/4 to 1 percent flight performance reserve, changed from 12-400K booster engines to 13-415K, and changed from 3.5 million pound fixed gross launch weight to 25,000 pound fixed payload.

12 January 1971 - Resized orbiter and booster, changed from 13-415K to 12-520K booster engines.

3 February 1971 - Changed to 12-550K booster engines (no change in vehicle sizes). Added 2 RL-10 engines for on-orbit maneuvering.

3 March 1971 - Added 65K easterly and 40K polar missions (with no air-breathing engines).

3 April 1971 - Offloaded propellant to satisfy minimum Isp tank sizing requirements.

3 May 1971 - Changed from Pratt-Whitney to General Electric cruise engines. Revised booster cruise back propellant to reflect change to General Electric Engines.

Final Point Design - Changed from 10 second to 2.5 second coast time and reduced ascent velocity due to base pressure effect.

An expanded discussion of changes is included in the following section. For a detailed explanation of all changes during the phase B program, see the Mass Properties Change Analysis section of the individual monthly status reports.

2.2 Weight Change History (Design Mission) - Weight change histories for the total vehicle, delta orbiter and canard booster are presented in Figures 2.2-1, -2 and -3, respectively. The discrete points shown are the monthly mass properties (MP) status reports plus the detailed report presented as a portion of the 8th month data dump. For each of these reported points, the values of certain key parameters influencing weight are shown in Table 2.2-1.

Figure 2.2-1 Total Vehicle Weight Change History

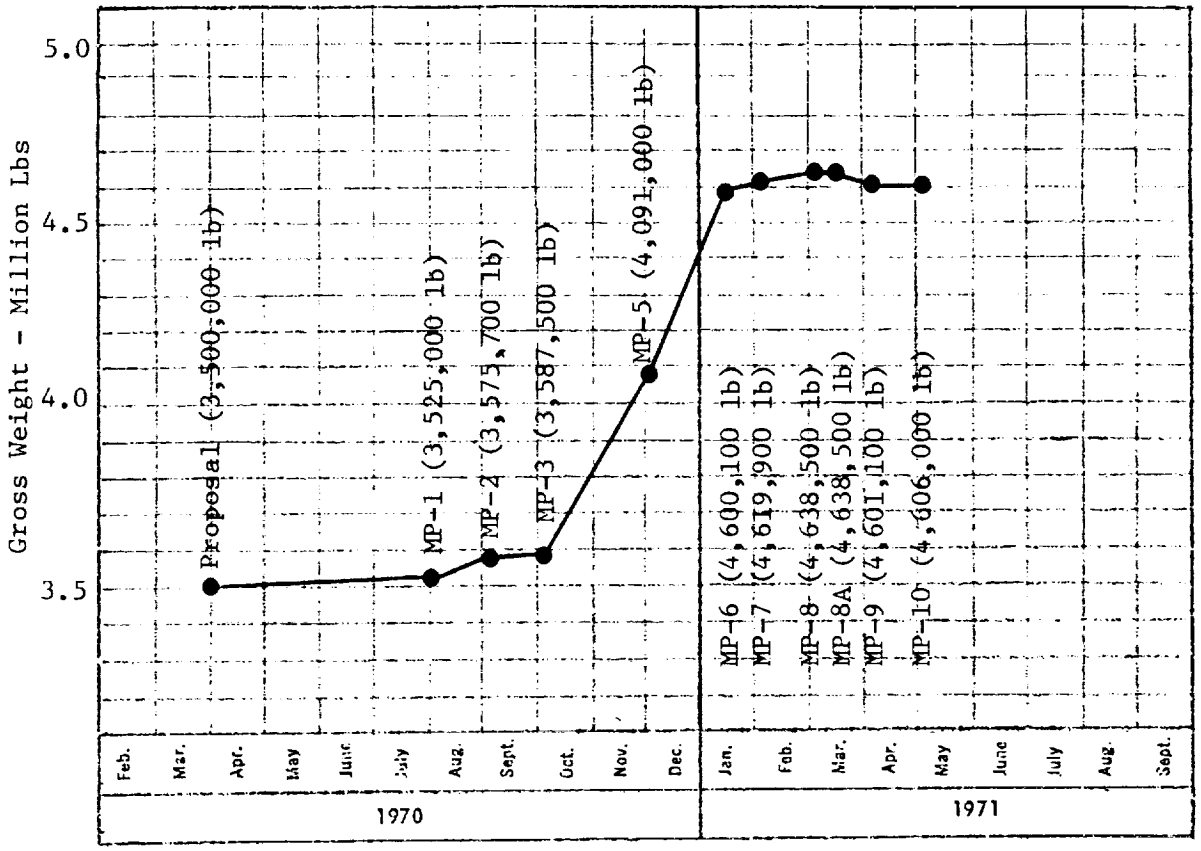
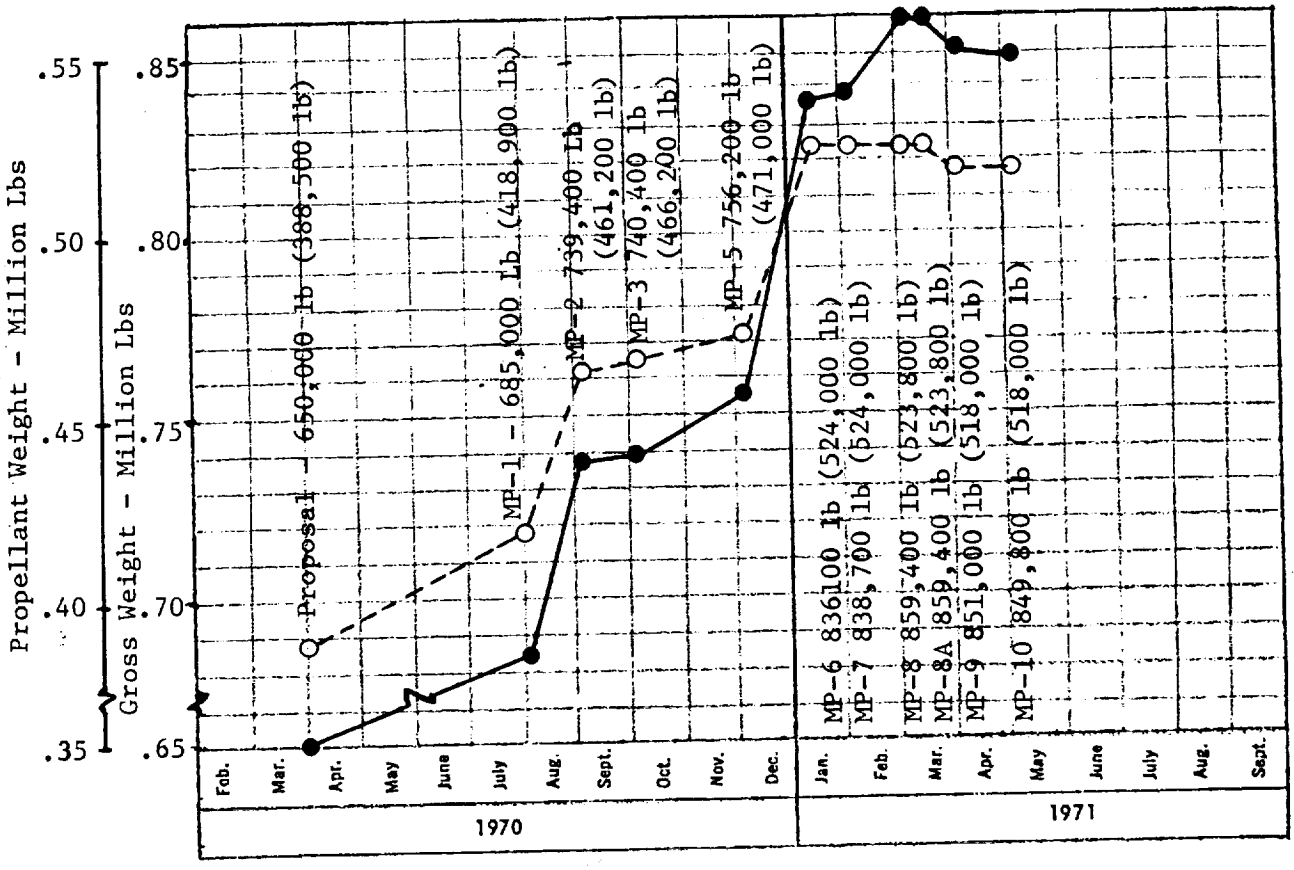


Figure 2.2-2 Orbiter Weight Change History

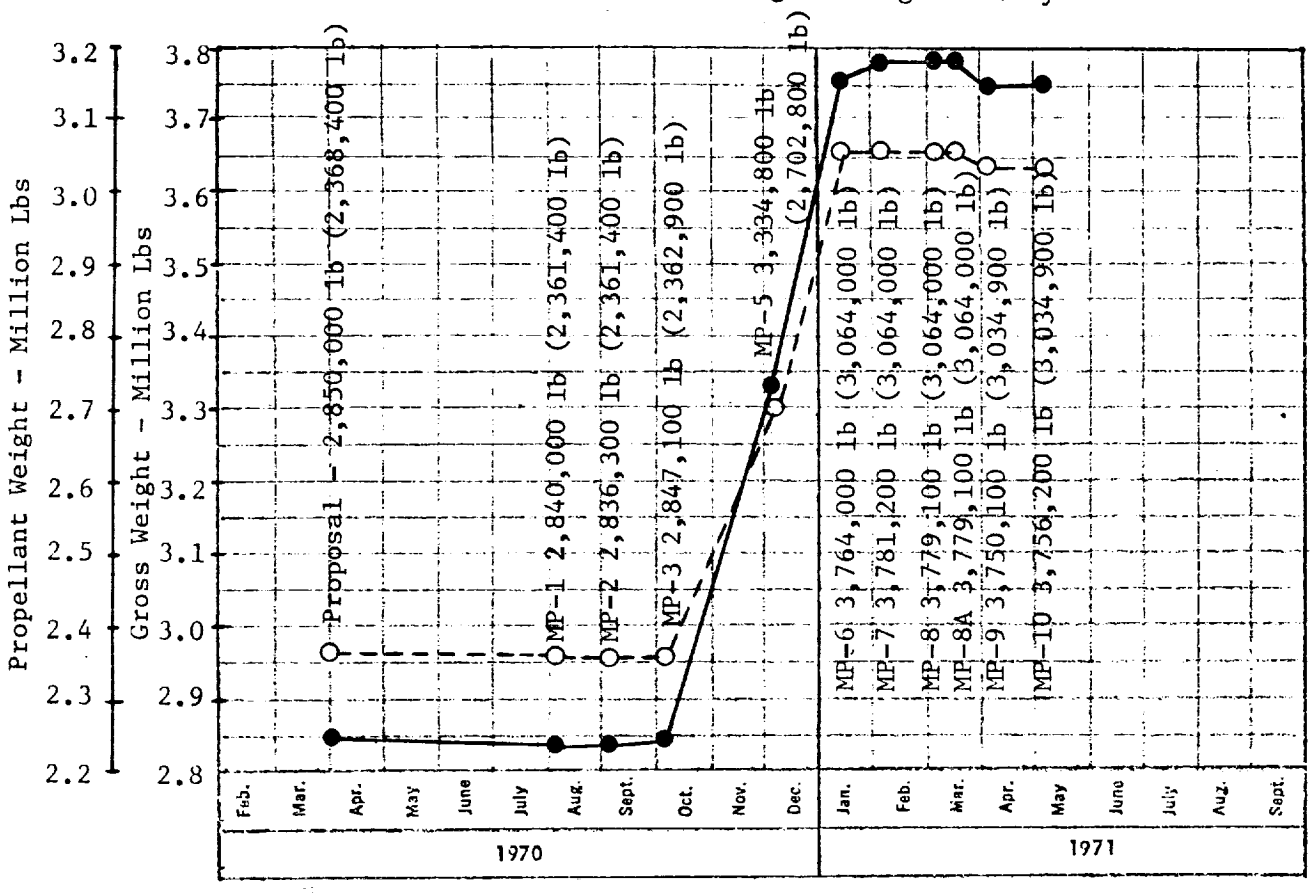


● Indicates Orbiter Gross Weight

○ Indicates Booster Usable Propellant Load

Data is shown based on the design mission as stated by the current system requirements at the time of each report. For reports MP-1 through MP-7 this is the 55 degree resupply mission launched from ETR. For reports MP-8 through the final, the design mission is the easterly mission from ETR. The critical mission from a performance standpoint, however, is the polar mission. In addition the auxiliary propellant tank size and airbreathing engine provisions are based on the 55 degree resupply mission.

Figure 2.2-3 Booster Weight Change History



● Indicates Booster Gross Weight

○ Indicates Booster Usable Propellant Load

At the time of the proposal, two boosters were presented, a delta wing version and a twin body version. At the beginning of the Phase B activity, a single body canard booster which combined many of the advantages of both the delta and twin body designs, was selected. During Phase B this configuration has evolved somewhat but has not been fundamentally changed. A single vertical tail has been replaced by two outboard verticals, the wing aspect ratio has increased progressively from 2.4 to 2.82 to 3.54, the vehicle has been resized from an initial propellant load of 2.36 million pounds to the current loading of 3.03 million pounds and the TPS has changed from metallic shingles on the lower portions and hot structure or the upper,to hardened compacted fibers over most of the outer surface.

From the beginning of Phase B thru January 1971 both a low crossrange (fixed straight wing) and high crossrange (delta) orbiter were studied. Effort on the low crossrange design was stopped at that time and results are described in Reference 1 . The current delta orbiter is similar to that initially shown in the proposal. The primary external differences are that it has been resized from a propellant loading of .388 million pounds to .518 million pounds and a single center vertical fin has been replaced with two outboard verticals.

The growth/uncertainty values shown in Table 2.2-1 are all expressed as a percentage of dry weight less growth/uncertainty, ascent and cruise engines. This same approach was used in the last monthly status report (MP-10). In reports MP-7 thru MP-9 growth/uncertainty was expressed as a percentage of dry weight less ascent engines and growth uncertainty. In all the reports prior to MP-7 it was expressed as a percentage of dry weight less growth uncertainty.

The gross launch weights shown in Table 2.2-1 are less booster propellant expended prior to liftoff. Also prior to MP-3 orbiter startup propellant was conservatively included in orbiter burnout weight. In MP-3 and subsequent reports this propellant was more properly staged prior to the nominal orbiter burn but as a result the sum of orbiter burnout and the nominal orbiter propellant load shown in the table do not add to the gross orbiter weight.

The vehicle reference lengths shown are measured from vehicle nose tip to the base of the fuselage. The total velocity shown is less flight performance reserves (FPR). An FPR of 3/4 percent of total ΔV was used from the proposal thru MP-3. In MP-4 and subsequent reports an FPR of 1 percent was used.

Reference 1 - MDAC Report No. E0354- Low Crossrange Shuttle System

Table 2.2-1 Change History of Key Parameters Influencing Weight

Item	Proposal Baseline	MP-1 3 Aug 70	MP-2 3 Sept 70	MP-3 2 Oct 70	MP-5 3 Dec 70	MP-6 12 Jan 71	MP-7 3 Feb 71	MP-8 3 Mar 71	MP-8A 15 Mar 71	MP-9 3 Apr 71	MP-10 3 May 71	Final Point Design
Design Mission	Resupply	Resupply	Resupply	Resupply	Resupply	Resupply (or Polar)	Resupply (or Polar)	East	East	East	East	East
Configuration												
Orbiter	Delta	Delta	Delta	Delta	Delta	Delta	Delta	Delta	Delta	Delta	Delta	Delta
Booster	Twin Body	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard	S.B.Canard
Growth/Uncertainty-%												
Orbiter	11.0	11.6	11.5	11.4	9.1	10.3	9.4	10.	9.7	10.	15.6	14.0
Booster	12.3	13.7	13.3	13.6	10.2	10.9	10.6	8.9	6.8	5.9	6.	10.0
Weights - Lb												
Payload	36200	13450	17770	16315	25000	25000	25000	79700	79700	74000	65000	65000
Gross Launch	3500000	3525000	3575700	3587500	4091000	4600100	4619900	4638500	4638500	4601100	4606000	4645100
Orbiter Gross	650000	685000	739400	740400	756200	836100	838700	859400	859400	851000	849800	860400
Booster Gross	2850000	2840000	2836300	2847100	3334800	3764000	3781200	3779100	3779100	3750100	3756200	3784700
Orbiter Burnout	261500	266100	278200	273600	284700	310700	313300	334100	334100	330400	329200	332200
Booster Burnout	481600	478700	474900	484200	632000	700000	717200	715100	715100	715100	721300	746100
Orbiter Propellant	388500	418900	461200	466200	471000	524000	524000	523800	523800	518000	518100	526300
Booster Propellant	2368400	2361400	2361400	2362900	2702800	3064000	3064000	3064000	3064000	3034900	3034900	3038600
Vehicle Refer. Length-ft												
Orbiter	157.5	157.5	159.7	159.7	158.3	160.3	160.3	160.3	160.3	160.3	160.3	160.3
Booster	162.	202.8	202.8	202.8	220.2	241.7	241.7	242.1	242.1	242.1	242.1	242.5
Velocity - ft/sec												
Total Ascent(less fpr)	29600	30092	29898	30060	30400	30068	29848	29187	29187	29150	29154	
Staging (Ideal)	16035	16078	15463	15389	16000	15500	15372	15260	15260	15221	15192	
Orbiter Maneuver	1500	1500	1500	1500	1500	1500	1500	676	676	676	900	900
Specific Impulse(Vac)sec.												
Orbiter	460	459	459	459	459	459.5	459	459	459	459	459	459
Booster	443.5	445	445	445	439.4	439.3	439	439	439	439	439	439
Orbiter Maneuver	385	396	396	396	396	396	444	444	444	444	444	444
Number of Ascent Engines	2/14	2/12	2/12	2/12	2/13	2/12	2/12	2/12	2/12	2/12	2/12	2/12
Thrust Per Engine - lb												
Orbiter (Vacuum)	460000	477000	477000	477000	477000	598000	632000	632000	632000	632000	632000	632000
Booster (Sea Level)	400000	400000	400000	400000	415000	520000	550000	550000	550000	550000	550000	550000
Booster Cruise Range -nm	410	474	474	400	431	428	428	457	457	457	457	450
Booster Cruise Fuel -lb	38300	38300	38300	42600	140080	148000	149000	160000	160000	160000	146000	131000

TABLE 2.2-2 – PHASE B ORBITER WEIGHT HISTORY

	WING	TAIL	BODY	TPS	LDG GEAR	ASCENT PROP	CRUISE PROP	AUX PROPUL.	PRIME POWER	ELECTRIC	HYD	SUR CONTROLS	AVIONICS	ECS	Personnel Prov.	Growth		Dry
MP-1	24232	9324	42836	36887	9182	27085	16236	4820	2266	3959		1461	4502	2159	210	18516		203675
Inc Sw 214 Ft^2 and Improve Loads	+1669																	
Area - 64 Ft^2 and Improve Loads		-110																
Body Scaled Up Sw = 336, Vol = 1331			+4383															
Rev Cockpit - Tunnel Est			+1231															
Rev O/B Interface Calc			+ 650															
S/B Prov Added			+ 200															
Integral Propellant Tanks			+10737			-10737												
			-2445															
Wp Vol Increased 19,760 to 22,229 Ft^3			+1363															
Increased Area Tps 538 Ft^2				1013														
Insulation to ECS				-2108										+2108				
Lower Temp with Rev Traj				-4412														
Increase Ldg Wt to 257,600 vs 253,200					+ 363													
Misc Compt Changes						1010												
4 Ext Mtd Eng to 3 Deployable							-684											
Cruise Fuel in Aux Prop Tanks							- 0	+1025										
Increased Surface Area												158						
Revised													-296					
Define as 10%																512		
MP-2	25901	9214	58955	31380	9545	17358	15552	5845	2266	3959	←	1619	4206	4267	210	19028		209305
Strength Analysis	2489		2400															
Remove Tip Fins		-9214		-3537														
Add Center Fin		4986																
Add Hypersonic Flap		478																
Reduce Area of Eng Compt Frg 170 Ft^2			-427									61						
Remove Fixed Hypersonic Flap			-411															
Updated Impulse & Sy Definition								1619										
Add Purge Liner														1420				
Hold at 10%																-14		
MP-3	28390	5464	60517	27843	9545	17358	15552	7464	2266	3959	←	1680	4206	5687	210	19014		209155
Recalc Tps to Fatest Areas, T				-145														
Revised Engine Wt-TVC Now Stage						-693	-795			95								
Rev.Pylon Nacelle Wt For Deploy Eng							-631											
Inc. Tank Size +4680#																		
More Conservative Tank Design								1301										
Single Rudder												-102						
Insulation & Purge Liner Recalc														2386				
10%																142		
MP-4	28390	5464	60517	27698	9545	16665	14126	8765	2266	4054		1578	4206	8073	210	19156		210713
Wing Area Down 827 Ft^2 Gepmetry Cng	987																	
Tail Area Down 120 Ft^2		-1058																
Body Chg-Area Down 1249 Ft^2			-2712															
6 Sided Insulation Bagging				1315														
Insulate Payload Bay to 300°F				442														
Est of Reduced Area				-1500														
Rev Eng.Wt.-TVC Now Stage						-693				95								
Rev Eng.Wt.-3 H to 4 JP Eng							-306											
Minor Tank Rev								41										
Rev.Analysis of Pwr Sy									-394									

TABLE 2.2-2 – PHASE B ORBITER WEIGHT HISTORY – CONT.

	WING	TAIL	BODY	TPS	LDG GEAR	ASCENT PROP	CRUISE PROP	AUX PROPUL.	PRIME POWER	ELECTRIC	HYD	SUR CONTROLS	AVIONICS	PERSONNEL ECS	PROV	GROWTH		DRY
MP-4 (Con't)												-102						
Single Rudder (See MP-3)														2065				
Recalc of Purge Liner/Insul																-3853		
Hold 25K																		
MP-5	29377	4406	57805	28100	9545	16665	15246	7505	1872	4054	←	1578	4206	7752	210	15161		203482
Narrower Body + Inc. Exp Wing	250																	
10° Dihedral	250																	
Elevons to Hot Structure	3278			*														
Resize: was 5330 Ft² now 5600	2045																	
Tit to Rene on V.Tail		795		*														
Resize: was 580 Ft²		299																
Add Payload Deploy Mech.			300															
Add SE (Prev prov. only)			416															
Siamese Tanks			-860															
Change to 520K Engines			945			6035												
Resize-S_w 20019 to 21330 Ft²			1994															
Reduce Protected Area				-1899*														
Resize				999				154										
Shorter Struts & Carbon Brakes					-1577													
Resize Ldg Wt 244K to 267K					432													
Improve Nacelle/Duct/Pylon							484											
Added Engines & Sy Req.								1141										
Rev. Analysis									-572	-554		2022	-206	48	-10			
Regrouped Hyd $y										-1800	1800							
10% Dry Wt Less Engines																6709		
MP-6	35200	5500	60600	27200	8400	22700	15730	8800	1300	1700	1800	3600	4000	7800	200	21870		226400
Elevons to Protected Struct	-3278			3319														
Rev. Estimate		+290	2314	442	563	952	-484			-28	-18	-104		-201	10			
Inc. Eng. Thrust Loads			664															
Inc. Cabin Size - Add Tunnel			672															
Prov. Pl Attach & Deploy for 65K			540															
Chg. to 550K Eng.						1623												
Chg. to RL-10								1187										
Fo, Fo, Fs,									419				467					
Fix Glow																-4368		
MP-7	30462	5790	64790	30961	8963	25275	15246	9987	1719	1672	1782	3496	4467	7599	210	17502		229921
Decrease Area 37 Ft², Stress Reanaly	-2151																	
Strength Review			-2369															
Shingle Design Chgs by Strength				1535														
Prop Tank Press 25 to 32/41								1818										
120V Liquid Cooled/Fo,Fo,Fs Chg									-120	-308			-102	-511				
Actuators Rev. (Fewer with Bigger Loads)												-515						
Fix Glow																139		
MP-8	28311	5790	62421	32496	8963	25275	15246	11805	1466	1364	1782	2981	4365	088	210	17641		227204
Inc. Actuator Loads (see MP-8)									412		234							
Rev. Act Wts (see MP-8)												-368						
Minor Equip. Rev.													-92					
Fixed Glow for Easterly Mission																968		
MP-8A	28311	5790	62421	32496	8963	25275	15246	11805	1878	1364	2016	2613	4457	7088	210	18609		228542

TABLE 2.2-2 – PHASE B ORBITER WEIGHT HISTORY – CONT.

	WING	TAIL	BODY	TPS	LDG GEAR	ASCENT PROP	CRUISE PROP	AUX PROPUL.	PRIME POWER	ELECTRIC	HYD	SUR CONTROLS	AVONICS	ECS	PERSONNEL PROV	GROWTH		DRY
	28311	5790	62421	32496	8963	25275	15246	11805	1878	1364	2016	2613	4457	7088	210	18609		228542
MP-8A		-50										-300						
Remove Body Flap Rotate Req.			200											200				
Beef Fl Door for 15 Knot Wind			-105															
Recald Pl Adapter			550															
Incorp Allow for Proof Test on Tank			400															
Tank 2014 to 2219			-500															
Decrease Tank Frame Spacing			100															
Inc. Gimbal Angle				-300														
Insulation Bagging Inconel to Hastel					230													
Add Androgynous Docking						200												
New Engine Weight								200										
Add O_2 Start Tank										-200						585		
Use Body as Power Return																		
Fix % Growth	28311	5740	63066	32196	9193	25475	15246	12005	1878	1164	2016	2313	4457	7288	210	19294		229852
MP-9	+1656		-1656															
Mlg Prov.	610		-610															
Abes Prov		-840	537	-272														
Delete Body Flap		122																
Reshape V. Tail																		
Increase SB size 50 to 65 Ft^2			-700															
Reduce Wing Attach Prov.			-1200				214											
Revise Contingency				-970														
Change Emittance .8 to .85				-1106														
Add Gold Coat to Purge Liner				-198														
Radiative Xchg in O_2 Tank						761	1365											
Revised Engine Accessory Wts.						250												
Add Main Tank Pressurization						643												
Updated Feed Sy Analysis							1432											
Add ABES Door Penalty								-70										
Delete 2 Fwd Yaw Engines								-374										
ACPS Accumulator Improve								-530										
Incorporate Cryo Allow								-148										
Mtg. and Prov.													-325					
Fo,Fo,Fs to Fo,Fs (Partial)														145				
Misc. Redefinitions of Comp.															168			
Update to Current Design Philosophy																2314		
Fix % Growth	30577	5022	59661	29650	9193	27129	18257	10883	1878	1164	2016	2313	4132	7433	378	21608		231294
MP-10																		

TABLE 2.2-2 – PHASE B ORBITER WEIGHT HISTORY – CONT.

	DRY WEIGHT	PERSONNEL	CARGO	RESIDUAL FLUIDS	INERT WEIGHT	RESERVE FLUIDS	IN-FLIGHT LOSSES	PROP CRUISE	PROP MAN/ACS	G.W. LESS ASCENT	ASCENT PROP	GROSS WEIGHT
MP-1	203675	400	13450	2731	220256	5503	4987	628	34678	267052	418948	685000
Sub-total	(5630)				(9958)					(11146)		(54355)
Scaled up			4320									
Ascent Tank Vapor				80								
OAMS/Cruise Residuals				-72								
Inc. Fuel Req. for Cruise Eng.						1565	-70	-128				
Inc. Main Prop.							186		115			
Inc. Ascent Prog						103	647				42209	
MP-2	209305	400	17770	2739	230214	7171	5750	500	34563	278198	461157	739355
Sub-total	(-150)				(-2010)					(-4012)		(1066)
▲Misc. 29808 to 30060			-1455									
Review Residuals				-405								
Reduced Man/ACS Fluids						+3953			-5584			
Rev. Ascent Prop							-780					
Inc. ECS Fluid Losses							409				5078	
MP-3	209155	400	16315	2334	228204	11124	5379	500	28979	274186	466235	740421
Sub-total	(-5673				(3617)					(11015)		(15760)
25K Fixed			8685									
Chg. to JP Fuel						866		1443				
Change from 3/4 to 1% Reserve						*						
Revised Man/ACS				-101		2750*	1119		-607			
Service Fluids Transfer				554					-554			
Cruise Fluids Transfer				+141					-141			
Ascent Prop				+ 11		1659*	859				4745	
Misc. Service Fluids							4					
MP-5	203482	400	25000	2939	231821	16399	7361	1943	27677	285201	470980	756181
Sub-total	(22918)				(24167)					(26899)		(79919)
Rev Service Fluids (Mostly Prime Pwr)				846		304	622					
Cruise Fluid				59		-1352		324				
Man/ACS				203		-503	-260		1710			
Ascent Prop				151		522	1355				53020	
MP-6	226400	400	25000	4188	255988	15380	9078	2267	29387	312100	524000	836100
Sub-total	(3521)				(3283)					(2600)		(2600)
RL-10-Eng				-238		*	*		*			
Man/ACS Fluids						312*	731*		-725*			
Update Cruise Prop Req'd								-1001				
MP-7	229921	400	25000	3950	259271	15692	9809	1266	28662	314700	524000	838700
Sub-total	(-2717)				(+4851)					(4851)		(+4847)
New Missions			7508									
Add Engine Oil				24								
Man/ACS Fluids				82		- 25	78		+446			
Service Fluids				-46		-230	+271					
Ascent Fluids						4	136				-4	
MP-8	227204	400	32508	4010	264122	14741	10294	1266	29128	319551	523996	843547

TABLE 2.2-2 - PHASE B ORBITER WEIGHT HISTORY - CONT.

	DRY WEIGHT	PERSONNEL	CARGO	RESIDUAL FLUIDS	INERT WEIGHT	RESERVE FLUIDS	IN-FLIGHT LOSSES	PROP CRUISE	PROP MAN/ACS	G.W. LESS ASCENT	ASCENT PROP	GROSS WEIGHT
MP-8	227204	400	32508	4010	264122	14741	10294	1266	29128	319551	523996	843547
Sub-total	(1338)				(0)					(0)		(0)
New Mission			-1435									
Inc. Hydraulic Fluid				97								
MP-8A	228542	400	31073	4107	264122	14741	10294	1266	29128	319551	523996	843547
Sub-total	(1310)				(-4421)					(-2392)		(-8146)
New Mission			-5518									
Ascent Fluids				-213		(-78)	(+1907)				-5754	
Increased Pull Thru Prop							966					
Increased Start-up Losses							1146					
Rev. Eng. Wet Wts						-322						
Decreased Shut Down Loss							-224					
Rev Press Wt.						65						
Rev. Feed Line Residuals						194						
?						-15	+19					
LH Cool Aux. Prop							200					
MP-9	229852	400	25555	3894	259701	14663	12401	1266	29128	317159	518242	835401
Sub-Total	(1442)				(1093)					(1)		(1)
New Mission			-555									
Cruise Prop				-20				-120				
Man/ACS						-299	-370		-297			
90% Crew + NASA GFE List		226										
MP-10	231294	626	25000	3874	260794	14364	12031	1140	28831	317160	518242	835402

TABLE 2.2-3 - PHASE B BOOSTER WEIGHT HISTORY

	WING	TAIL	BODY	TPS	LDG GEAR	ASCENT PROP	CRUISE PROP	AUX PROP	PRIME POWER	ELEC TRICAL	HYD	SURF CONT	AVIONICS	ECS	PERSON-NEL	GROWTH		DRY WT
MP-1	43136	21964	111215	35052	17610	86316	31503	2362	880	1235	4640	3290	3808	495	147	36405		400058
New Engine Wts						4692												
10%																-509		
MP-2	43136	21964	111215	35052	17610	91008	31503	2362	880	1235	4640	3290	3808	495	147	35896		404241
Isogrid Calc vs t			2191															
Rev Inter Tank Struct			-775															
Add Skirt for Eng. Ht. Protect			2860															
Inc. Tank Vol							150											
10%																1381		
MP-3	43136	21964	115491	35052	17610	91008	31653	2362	880	1235	4640	3290	3808	495	147	37277		410048
Inc Reentry wt & L.F. 3.0 to 4.5 AR 2.82 vs 2.40	6012																	
Reduce V Tail 1100 to 437 sq.ft.		-9662																
10 vs 8 Cruise Engines		2633					3474											
Tanks Resized Wp 2702838# was 2362933# plus 1 more engine			12436															
Protected Area from 55% to 100%				27840														
Inc. Entry wt					2130													
Fixed Boost Pumps						-6000												
Rev. Fill/Drain Sy Calc.						161												
Rev. Feed Line Calc						-3107												
Rev. Vent/Press Sy						1052												
Rev. Pneumatic Sy						1148												
Add 1 Engine (12 to 13)						6133												
Rev. Calc of Aux Prop								848										
Add Jet Flap												400						
Increased Pwr Req'd									148									
Boost Eng. TVC on Stage											400							
Now 9.6% vs 10%																-3290		
MP-5	49148	14935	127927	62892	19740	90395	35126	3210	1028	1235	5040	3690	3808	495	147	33987		452803
Entry Wt. 670K vs 600K AR 3.54 vs 2.81	3208																	
Misc Recalc		-148																
Resize Wp 3064K was 2703K			21193															
Increased Area-Body 4%&2%				3246														
Wing				234														
Recalc Base Heat Protect				2057														
Add Purge Prov				3642														
Temp Chg with ECR				-2412														
Inc. Ldg. Wt.					2772													
12 520K vs 13 415 Engines						18291												
Delete Null Drive from TVC Act						-1800												
Secondary Tank Vent						67												
Isolation Values in Vent System						254												
Inc Length Feed/Press Lines						540												
Add Cruise Prop							1370											
Impulse 695K lb sec vs 500K								470										
Larger Rudder/Elev												1220						
Maintain 700K B.O. Wt.																6371		
MP-6	52356	14787	149120	69659	22512	107747	36496	3680	1028	1235	5040	4910	3808	495	147	40358		513378

TABLE 2.2-3 - PHASE B BOOSTER WEIGHT HISTORY - CONT.

	WING	TAIL	BODY	TPS	LDG GEAR	ASCENT PROP	CRUISE PROP	AUX PROP	PRIME POWER	ELEC TRICAL	HYD	SURF CONT	AVIONICS	ECS	PERSON-NEL	GROWTH		DRY WEIGHT
MP-6	52356	14787	149120	69659	22512	107747	36496	3680	1028	1235	5040	4910	3808	495	148	40358		513378
Revised Airfoils on Wing	-140																	
Reconfig Tail		52																
Inc. Landing Weight					+630													
Inc. Eng. Thrust 520 to 550K																14027		
Hold 717,200 B.O.Wt																308		
MP-7	52216	14839	149120	69659	23142	107747	36496	3680	1028	1235	5040	4910	3808	495	147	54693		528255
Redistribute 550K Pend Chg																		
Thrust Struct			1850													-1850		
Base Heat Protect				493												-493		
Main Engines						7200										-7200		
TVC Actuators						3528										-3528		
Feed System						335										-335		
SIVB Insul vs ADV Honeycomb			573															
Purge Sy to ECS				-3642										+3642				
TVC Fail Slave vs Fail Null						-2328					250							
Update Weights to Layouts						619	429	893		128					17			
Turbo's 320 HP to 450 HP									229									
Transfer Consoles and Inst Pnl													-126		126			
Maintain 717200 B.O. Wt.																-7898		
Refined Wing Loads	-1230																	
Inc. Elsv. Loads/Deflection	472																	
MP-8	51458	14839	151543	66510	23142	117101	36925	4573	1257	1363	5290	4910	3682	4137	290	33389		520409
Reduced Loads/Inc in Isogrid			-4189															
Rev. Allowables on Bkhds			-1028															
Larger Nose Area			173															
Initial Est of Cockpit			348															
Miscellaneous			-285															
Complete Recalc of TPS				10329														
Reduced Ldg. Wt.					-332													
Update Wt. to L.O. Calc + Pneu System						1111												
+ Prop Level						-25	130	17										
Helium to Residual						-67												
Feed Sy Misc. Changes							61											
60 KVA vs 50 KVA Alt									441									
Fo, Fo, Fe.													250					
Update to Latest Schematic														506				
Maintain 717200 B.O. Wt.																-7419		
MP-8A	51458	14839	146562	76839	22810	118120	37116	4590	1698	1363	5290	4910	3932	4643	290	25970		520430
2219 vs 2014 for Tank			929															
New Eng. Wt.						840												
Additional Ducting						1207												
Lox Dia to 22" from 19"						1060												
Hold 717200 B.O. Wt.																-3051		
MP-9	51458	14839	147491	76839	22810	121227	37116	4590	1698	1363	5290	4910	3932	4643	290	22919		521415

TABLE 2.2-3 – PHASE B BOOSTER WEIGHT HISTORY – CONT.

	WING	TAIL	BODY	TPS	LDG GEAR	ASCENT PROP	CRUISE PROP	AUX PROP	PRIME POWER	ELECT RICAL	HYD	SURF CONT	AVONICS	ECS	PERSON-NEL	GROWTH	DRY WEIGHT
MP-9	51458	14839	147491	76839	22810	121227	37116	4590	1698	1363	5290	4910	3932	4643	290	22919	381415
Detail Weight Calc	2306							26	25								
Xfer Canard Carry Thru		-3237	3237														
Chg P & W to G.E. Engines		1400		278			3330										
Reduce Lox Ullage Press 30 to 18			-3276														
Sidewall Weld Lands			1403														
Tank Proof Test Gradient			630														
Detail Calc - Inter Tank			958														
- Aft Skirt & Thrust			5994														
- N.G. Prov			-196														
- M.G. Prov			3568														
- Canard Attach			578														
- Bogey for Wing			-2529														
- Separation Sy			-759														
- Base Heat Shield				-336													
Inc. Ldg Weight					790												
Inc. Loads TVC Actuators						1512											
Xfer TVC Hydraulics						2188					-2188						
Detail Calc - Chilldown System						91											
- Fwd Cruise Prop Tank							-1722										
Inc. Line Sizes Prop Distrib.								271									
Detail Calc - Surface Cont Sy												2016					
- Hyd											2941						
Fo, Fa,													-228				
Maintain 71700 B.O. Weight																1329	
MP-10	53764	13002	157099	76781	23600	125018	38724	4887	1723	1363	6043	6926	3704	4643	890	24248	541815

TABLE 2.2-3 - PHASE B BOOSTER WEIGHT HISTORY - CONT.

25K 55° MISSION W/ABES

	DRY WEIGHT	PER-SONNEL	RESIDUAL FLUIDS	INERT WEIGHT	RESERVE FLUIDS	INFLIGHT LOSSES	CRUISE	PROP MAN/ACS	G.W. LESS ASCENT	ASCENT PROP	GROSS WEIGHT
MP-1	400058	400	5299	405757	10915	33310	27395	1347	478724	2361387	2840111
Sub-total	(4183)			(3996)					(-3787)		(-3787)
Rev Est			-187								
Rev Wts for Prop in Lines & Engines						-7783					
MP-2	404241	400	5112	409753	10915	25527	27395	1347	474937	2361387	2836324
Sub-total	(5807)			(6053)					(9184)		(10730)
Gox Ullage 515° vs 500°			-270								
Tank Pressure			+284			-284					
ACPS Accumulator Fluids			+119		260						
Inc. Cruise Prop			76		385		3858				
APU Fluids					324	30					
O_2 Eng Tap off Temp 800 vs 500°						-1140					
Ldg Press 18 psi vs 19						- 163					
Miscellaneous						- 154		20			
Revised Ascent Load										1546	
MP-3	410048	400	5358	415806	11884	23811	31253	1367	484121	2362933	2847054
Sub-total	(42755)			(45769)					(47879)		(48784)
J.P. 4 vs L.H			3087		39458		58391				
APU Power UP			87			1539					
ACPS in Lines Recalc			-160								
Eng. Line Fluids/Rev. Spec.						3331					
Redesigned Lox Sump						-1500					
Add Pneumatic Sy Press						100					
Rev. C lc.								260			
Ascent Prop Resized						531				339905	
MP-5	452803	400	8372	461575	51342	27812	89644	1627	632000	2702838	3334838
Sub-Total	(60575)			(62037)					(68000)	(361162)	(429162)
Inc. Cruise Prop			583		561		7356				
Resize Ascent Prop			710			936					
Misc. Reanalysis of Fluids			173			17					
Inc. Acs. Impulse			-4		54	76		351			
Inc. Dumped in Cruise Prop					-40000		+40000				
Eng Residuals						1526					
Revised Shutdown Criteria						-4900					
APU Fuel						-3060		3060			
MP-6	513378	400	9834	523612	11960	22390	137000	5038	700000	3064000	3764000
Sub-total	(14877)			(14897)					(17200)		(17200)
Cruise Prop Inc. (Ldg Wt - Hi L/D)			20				1000				
Pending Ascent Eng. Chg - Residuals						1303					
MP-7	528255	400	9854	538509	11960	23693	138000	5038	717200	3064000	3781200

TABLE 2.2-3 - PHASE B BOOSTER WEIGHT HISTORY - CONT.

25K 55° MISSION W/ABES

	DRY WEIGHT	PER-SONNEL	RESIDUAL FLUIDS	INERT WEIGHT	RESERVE FLUIDS	INFLIGHT LOSSES	CRUISE	PROP MAN/ACS	G.W. LESS ASCENT	ASCENT PROP	GROSS WEIGHT
MP-7	528255	400	9854	538509	11960	23693	138000	5038	717200	3064000	3781200
Sub-Total	(-7846)			(-7900)					(0)		(0)
Revised Shutdown Techniques						-1713					
H_2(was 26 psi/450° now 25 psi/570°)			-106								
O_2(was 26 psi/515° now 18 psi/535°)			-179								
Inc. Cruise Propellant			220								
Range 457 vs 433							6500				
L/D Rev.							4500				
APU Fuel reduced - Hydraulic System			-29		-386	-181		-1933			
Decreased ASCS Impulse 695K to 500K					-133			- 756			
APU Fuel						+1127		-1127			
25K 55° Mission Require			40				2000				
MP-8	520409	400	9800	530609	11441	22928	151000	1222	717200	3064000	3781200
Sub-Total	(21)			(88)					(0)		(0)
Pneumatic System He			+67			-66		-22			
MP-8A	520430	400	9867	530697	11441	22862	151000	1200	717200	3064000	3781200
Sub-Total	(985)			(985)					(0)		(-29100)
Inc. Eng Wt Residuals						-2003					
Add Main Tank Prepressure gas						1018					
Rev.Propellant Loading										-29100	
MP-9	521415	400	9867	531682	11441	21877	151000	1200	717200	3034900	3752100
Sub-Total	(20400)			(20000)					(0)		(0)
Dec Cruise Prop with O.E. Engines			-400		-1000		-19000				
MP-10	541815	400	9467	551682	10441	21877	132000	1200	717200	3034900	3752100

Prior to MP-6 main tank sizes were based on the nominal Isp's and resulting propellant loads shown. From MP-6 thru MP-8A the tanks are oversized by the ratio of nominal to minimum Isp, i.e. the tanks will actually hold more propellant than that shown. In MP-9 and MP-10 the tanks were not resized but the nominal propellant load was redefined by first calculating performance with full tanks and minimum Isp's and then changing to nominal Isp's and calculating how much propellant could be offloaded while maintaining the same performance, i.e. allowable growth/uncertainty. In all cases, minimum Isp's are 3 seconds less than the nominal values shown and tanks volumes include a minimum ullage space of 3 percent.

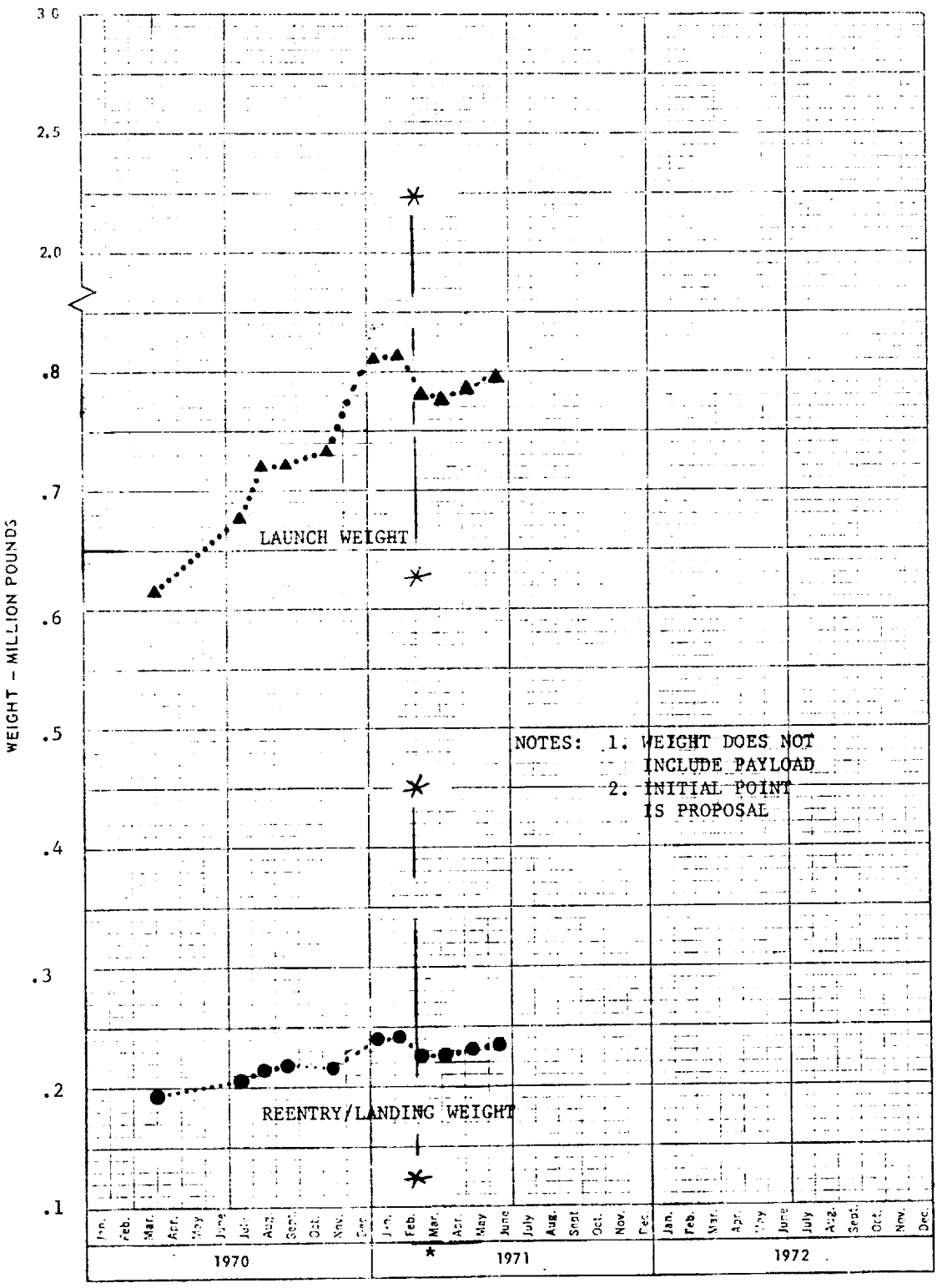
The large change in cruise fuel between MP-3 and MP-5 is due to the change from liquid hydrogen to JP-4. Subsequent increases were due to minor changes in cruise range and vehicle cruise weight. The reduction shown for MP-10 is due to the change from Pratt and Whitney to General Electric cruise engines which resulted in an increase in engine weight but a reduction in cruise fuel.

A summary explanation of the major differences between the various MP reports shown in Table 2.2-1 is presented in Tables 2.2-2 and -3. Changes from MP-10 are described in the following section.

2.3 Monthly Weight History Charts - An update of the weight history charts from the monthly mass properties status reports is presented in Figures 2.3-1, -2 and -3. Easterly mission mass properties change summaries which explain differences between the last monthly status report (MP-10) and the data presented in this report are presented in Table 2.3-1 and -2 for the orbiter and booster respectively.

FIGURE 2.3-1 WEIGHT HISTORY

CONFIGURATION HIGH CROSS RANGE DELTA ORBITER | BY | DATE 15 June 1971



* CHANGED FROM 55°, 270 NM ORBIT, 25K WITH ABES TO 28.5°, 100NM ORBIT, 65K W/O ABES FOR REFERENCE MISSION

FIGURE 2.3-2 WEIGHT HISTORY

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

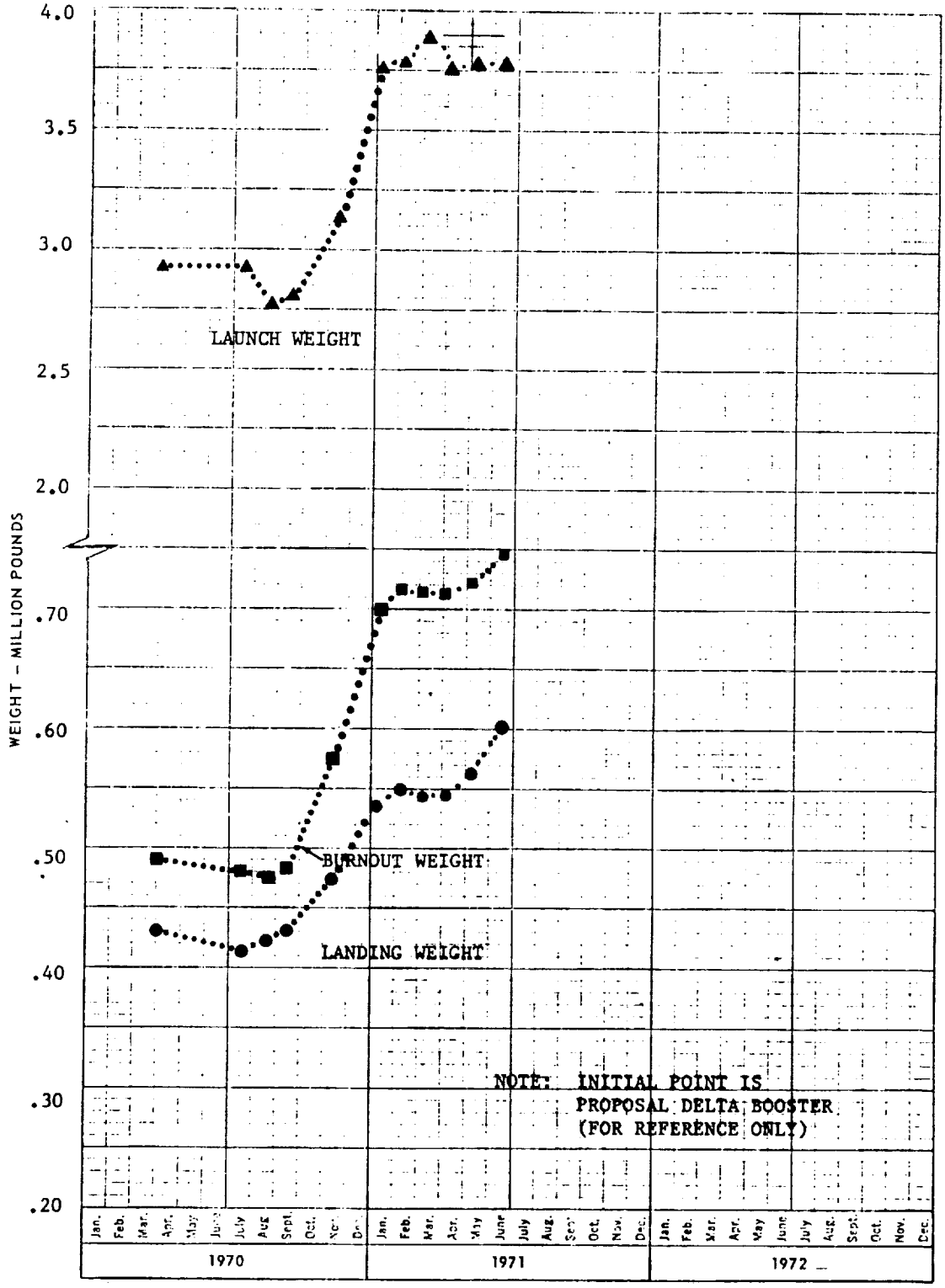
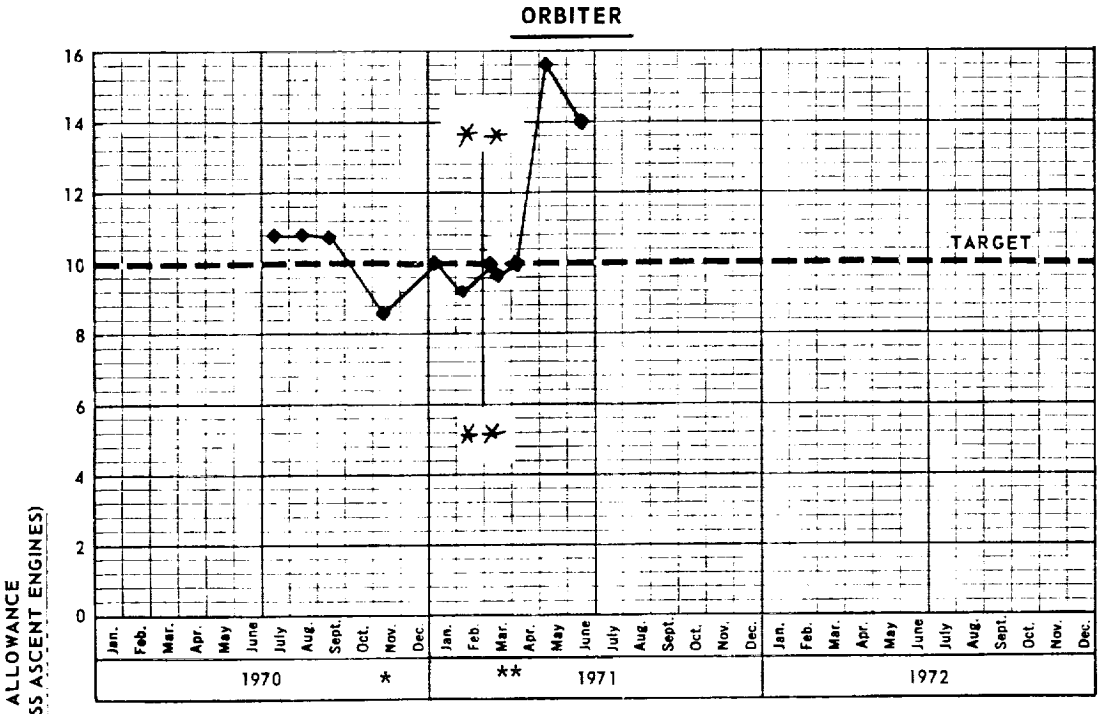
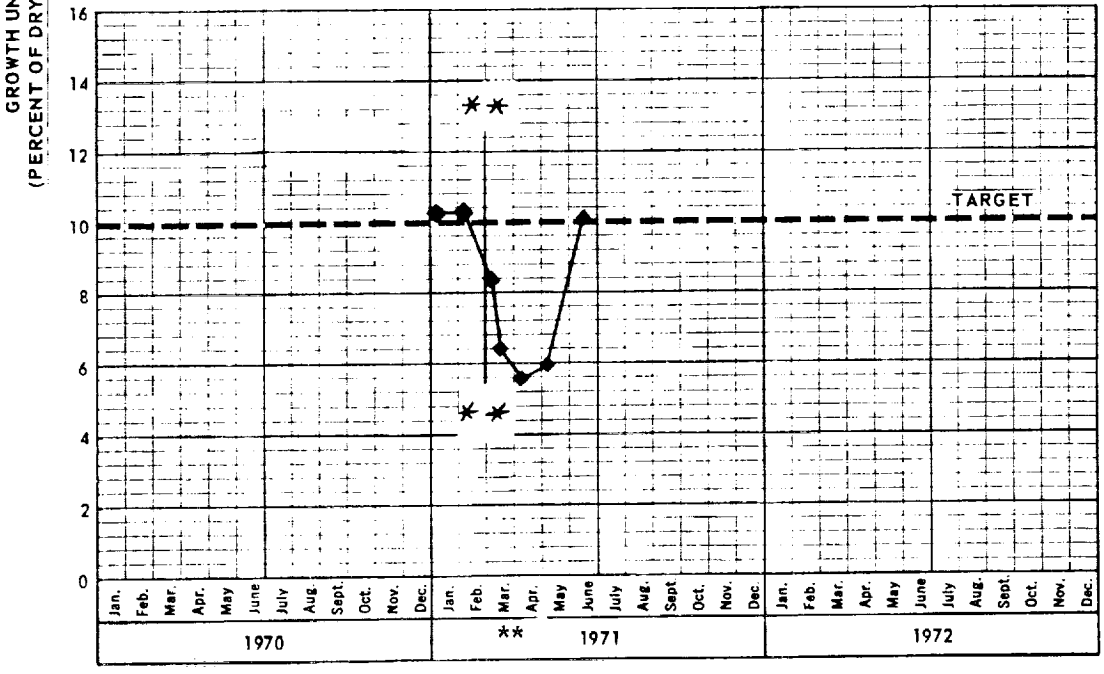


FIGURE 2.3-3	WEIGHT HISTORY (GROWTH UNCERTAINTY ALLOWANCE)				
CONFIGURATION	HIGH CROSSRANGE	BY		DATE	15 June 1971



* Target Value Changed from 10% of dry weight to 10% of Dry Weight less ascent engines.



** REFERENCE MISSION CHANGED FROM 55°, 270 NM ORBIT, 25K P.L. WITH ABES TO 28.5°, 100 NM ORBIT, 65K P.L. W/O ABES FOR REFERENCE MISSION

TABLE 2.3-1 MP-10 TO DETAILED REPORT (ANALYSIS VEHICLE)

MASS PROPERTIES CHANGE SUMMARY

CONFIGURATION: 65K EASTERLY MISSION DATE: 06/14/71

SUBSYSTEM	LAST REPORT 04/23		CURRENT REPORT 06/14		CHANGE		NOTE NO.*
	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G.** IN.	
WING	30577.	1748.	31587.	1736.	1010.	-.22	1
TAILS	5022.	2052.	5104.	2054.	82.	.26	2
BODY	59661.	1290.	55500.	1282.	-4161.	4.22	3
THERMAL PROT	29650.	1397.	32847.	1353.	3197.	-7.69	4
LANDING/DOCK	9193.	1470.	10551.	1436.	1358.	-1.60	5
PROP-ASCENT	27129.	1853.	26637.	1863.	-492.	.36	6
PROP-CRUISE	1832.	1562.	574.	1542.	-1258.	-.51	7
PROP-AUXIL	10883.	1281.	11877.	1281.	994.	-.86	8
PRIME POWER	1878.	1077.	2272.	1015.	394.	-1.36	9
ELEC DIST	1164.	792.	1303.	832.	139.	-.20	10
HYDRA DIST	2016.	1820.	2760.	1705.	744.	-.30	11
SURF CONTROL	2313.	1800.	4901.	1944.	2588.	6.83	12
AVIONICS	4132.	1031.	4588.	1030.	456.	-.05	13
ENVIR CONTRL	7433.	1124.	7849.	1124.	416.	-.68	14
PERSNL PROV	378.	940.	430.	862.	52.	-.08	15
ABORT	0.	0.	0.	0.	0.	-.00	
BALLAST	0.	0.	0.	0.	0.	-.00	
GROWTH/UNCER	27354.	1483.	25363.	1479.	-2001.	-.47	16
DRY WEIGHT	220625.	1483.	224143.	1479.	3517.	-4.00	
PERSONNEL	626.	940.	626.	951.	0.	.02	17
LANDED CARGO	40000.	1420.	40000.	1420.	0.	-.00	

TABLE 2.3-1 (CONT)

MASS PROPERTIES CHANGE SUMMARY

CONFIGURATION: 55K EASTERLY MISSION DATE: 06/14/71

SUBSYSTEM	LAST REPORT 04/23		CURRENT REPORT 06/14		CHANGE		NOTE NO.*
	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G.** IN.	
RESID FLUIDS	3670.	1425.	4001.	1385.	331.	-.56	19
INERT WEIGHT	264921.	1471.	268770.	1469.	3849.	-3.00	
RESERVE FLDS	6093.	1725.	6651.	1712.	559.	.19	19
LANDING WT	271014.	1477.	275421.	1474.	4407.	-3.00	
CRUISE PROP	0.	0.	37.	17969.	37.	2.24	20
FLIGHT WT	271014.	1480.	275458.	1476.	4444.	-4.00	
ENTRY ACS	1000.	1684.	1834.	1477.	834.	-.77	21
ENTRY WT	272014.	1480.	277292.	1476.	5279.	-4.00	
RETRO PROP	5434.	1741.	5536.	1741.	102.	.00	22
PRE RETRO WT	277448.	1485.	282828.	1481.	5380.	-4.00	
ON ORB LOSS	12528.	1546.	11360.	1600.	-1168.	-2.26	23
LANDED CARGO	-40000.	1420.	-40000.	1420.	0.	-.00	
ASCENT CARGO	65000.	1420.	65000.	1420.	0.	-.00	
ON ORBIT WT	314976.	1487.	319188.	1481.	4212.	-6.00	
MANEUV PROP	1956.	1741.	1993.	1741.	37.	.03	24
DUMPED PROP	12240.	813.	10600.	813.	-1640.	3.25	25
INJECTION WT	328172.	1463.	331781.	1461.	2608.	-2.00	
ASCENT PROP	129516.	887.	131860.	887.	2344.	-1.70	26
75% BURN	458688.	1331.	463641.	1329.	4953.	-2.00	
ASCENT PROP	129516.	888.	131701.	888.	2185.	-1.28	27
50% BURN	588204.	1234.	595342.	1231.	7138.	-3.00	

TABLE 2.3-1 (CONT)

MASS PROPERTIES CHANGE SUMMARY

CONFIGURATION: 65K EASTERLY MISSION DATE: 06/14/71

SUBSYSTEM	LAST REPORT 04/23		CURRENT REPORT 06/14		CHANGE		NOTE NO.*
	WEIGHT LB.	Y C.G. IN.	WEIGHT LB.	Y C.G. IN.	WEIGHT LB.	Y C.G.** IN.	
ASCENT PROP	129516.	763.	131569.	763.	2053.	-1.10	28
95% BURN	717720.	1149.	726911.	1147.	9191.	-2.00	
ASCENT PROP	129518.	592.	131570.	592.	2052.	-1.14	29
IGNITION	847238.	1064.	858481.	1062.	11243.	-2.00	
STARTUP	2518.	826.	1962.	861.	-656.	.26	30
LAUNCH WT	849756.	1063.	860443.	1061.	10687.	-2.00	

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* THESE NUMBERS CORRESPOND TO THE CHANGE ANALYSIS ITEM NUMBERS.
** THESE ARE CHANGES IN THE TOTAL VEHICLE C.G. CAUSED BY SYSTEM WEIGHT OR C.G. CHANGES.

TABLE 2.3-1 (CONT)
MASS PROPERTIES CHANGE ANALYSIS

1. WING INCREASE OF 1010 POUNDS DUE TO 655 POUNDS OF STRUCTURE FOR INCORPORATION OF DETAILS OF THE ANALYSIS VEHICLE FINAL CONFIGURATION AND A 355 POUND INCREASE IN LEADING EDGE AND STRAKE WEIGHT DUE TO CORRECTING THE STRAKE AND LEADING EDGE AREA AND UNIT WEIGHTS FOR THE ANALYSIS VEHICLE FINAL CONFIGURATION.

2. TAIL INCREASE OF 82 POUNDS DUE TO INCORPORATION OF FINAL DETAILS OF THE ANALYSIS VEHICLE: STRUCTURE - 47 POUNDS, LEADING EDGE - 35 POUNDS.

3. BODY DECREASE OF 4161 POUNDS: 1045 LB. DECREASE DUE TO TRANSFER OF PAYLOAD ATTACHMENT AND DEPLOYMENT TO THE LANDING/DOCKING SYSTEM: 1630 LB. DECREASE DUE TO TRANSFER OF INTERSTAGE ATTACHMENT MECHANISM (DRAG LONGERON RETAINED IN BODY.) TO THE LANDING/DOCKING SYSTEM. THE REMAINING 2675 POUNDS DECREASE IS DUE TO DETAIL ANALYSIS OF THE STRUCTURAL COMPONENTS AS COMPARED TO THE ESTIMATES PREVIOUSLY CARRIED.

4. INCREASE IN THE ANALYSIS VEHICLE THERMAL PROTECTION OF 3197 POUNDS AS COMPARED TO MP-10 IS DUE TO THE ANALYSIS VEHICLE TPS BEING CONSISTENT WITH MP-A. THE WEIGHT DECREASES OF MP9 AND MP10 ARE IN THE FINAL DESIGN BASELINE BUT NOT THE ANALYSIS VEHICLE.

5. THE LANDING/DOCKING GROUP HAS INCREASED 1359 POUNDS DUE TO THE FOLLOWING: THE ALIGHTING GEAR DECREASED BY 596 LB. AS A RESULT OF A DECREASE IN GEAR LENGTH BROUGHT ABOUT BY THE NEW WING. DECELERATION CHUTE SIZE REDUCTION FROM 50 FEET TO 40 FEET DIAMETER -126 LB. THE INCORPORATION OF A DETAILED EVALUATION OF THE ANDROGYNOUS DOCKING SYSTEM +210 LB. TRANSFER OF INTERSTAGE ATTACH +803 LB., PAYLOAD HANDLING +647 LB., AND TUNNEL +410 LB. FROM BODY STRUCTURE.

6. CHANGE TO AEROSPACE RECOMMENDED PRACTICE (ARP 735) MINIMUM GAUGES WHERE APPLICABLE. IMPROVED GIMBAL ACTUATOR WEIGHTS. INCORPORATE RESULTS OF A MORE DETAILED ANALYSIS.

7. RECODE ENGINE DOORS TO WING STRUCTURE (-1432 LB.). RESIZE FUEL TANK (-27 LB.). ADD INSULATION ON CRUISE TANK

TABLE 2.3-1 (CONT)
MASS PROPERTIES CHANGE ANALYSIS

(+44 LB.). INCORPORATE DETAIL ANALYSIS OF FEED SYSTEM (+96 LB.). ADD CONTINGENCY TO ITEMS NOT REMOVED FOR EASTERLY MISSION (+61 LB.).

8. ADD ONE ACS ENGINE AND INCORPORATE SCHEMATIC CHANGES. INCORPORATE RESULTS OF A MORE DETAILED ANALYSIS.

9. ADDED FOURTH APU UNIT (+138 LB.). INCREASED FUEL CELL UNIT WEIGHT (+200 LB.). OTHER ASSOCIATED CHANGES (+56 LB.).

10. INCREASED AC GENERATOR WEIGHT BASED ON BETTER VENDOR DATA AND ADDED LANDING LIGHTS (+139 LB.).

11. ADDED FOURTH SYSTEM AND REVISED POWER PROFILE DUE TO TRANSONIC LOADS.

12. LOADS INCREASE DUE TO TRANSONIC CONTROL REQUIREMENTS.

13. ADD MAINTENCE RECORDER (+100 LB.) AND NUMEROUS OTHER EQUIPMENT LIST CHANGES FOR SYSTEM UPDATE (+356 LB.).

14. CHANGE RADIATOR SIZE TO 615 SQUARE FEET. ANALYZE RADIATOR STRUCTURE AND HINGE REQUIREMENTS FOR 1 G AND 15 KNOT WIND (+489 LB.). REANALYZE TOTAL SYSTEM (-73 LB.).

15. INCREASE WEIGHT OF FREEZER AND ADD WATER STORAGE TANK.

16. ADJUSTED TO MAINTAIN ALLOWABLE ORBITER INJECTION WEIGHT.

17. INCORPORATE DETAIL C.G. ANALYSIS.

18. INCREASED CAPACITY OF FREON COOLING LOOP (+214 LB.). ADDITIONAL WATER IN CABIN COOLING LOOP (+42 LB.). INCREASED ATMOSPHERE SUPPLY (+32 LB.). ADDITIONAL HYDRAULIC FLUID (+105 LB.). INCREASED ASCENT PROP. RESIDUALS (+1 LB.);DECREASED MANEUVER TANK RESIDUALS (-63 LB.).

19. PNEUMATIC SYS RESERVES (+19 LB.). REVISED MANEUVER RESERVES

TABLE 2.3-1 (CONT)

MASS PROPERTIES CHANGE ANALYSIS

(+373 LB.). REVISED ECLS RESERVES (+18 LB.). ADDED APU RESERVES (+148 LB.).

20. APU PROPELLANT NOW DISTRIBUTED THROUGHOUT MISSION. APU PROP USED DURING SUBSONIC FLIGHT (+37 LB.). ALSO INCLUDES LANDING GEAR RETRACTION.

21. APU PROP USED DURING ENTRY (+636 LB.). AUX. SYSTEM BOILOFF DURING ENTRY (+160 LB.). AUX. SYSTEM COMPARTMENT PURGE AND VENT LOSS DURING ENTRY (+38 LB.).

22. REVISED MANEUVER PROPELLANT LOADING.

23. INFLIGHT LOSSES NOW DISTRIBUTED THROUGHOUT MISSION. MINOR MANEUVER PROP. LOAD CHANGES.

24. REVISED MANEUVER PROPELLANT LOADING.

25. - 29. INFLIGHT LOSSES DISTRIBUTED AND INCREASED ASCENT PROPELLANT LOAD DUE TO LARGER FEED LINES AND INCREASED PROPELLANT DENSITY.

30. REANALYSIS OF ORBITER STARTUP REQUIREMENTS.

TABLE 2.3-2 MP-10 TO DETAILED REPORT
MASS PROPERTIES CHANGE SUMMARY

CONFIGURATION: CANARD BOOSTER EASTERLY MISSION DATE:06/16/71

SUBSYSTEM	LAST REPORT 04/21		CURRENT REPORT 06/14		CHANGE		NOTE NO.*
	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G.*** IN.	
WING	53764.	3767.	57954.	3797.	4190.	8.01	1
TAIL&CANARD	13002.	2811.	19214.	3278.	6212.	12.67	2
BODY	157099.	2852.	148599.	2816.	-8500.	-5.47	3
THERMAL PROT	76781.	3013.	84807.	3053.	8026.	4.34	4
LANDING GEAR	23600.	3138.	25885.	3098.	2285.	-1.90	5
ASCENT PROP	125018.	3716.	123320.	3708.	-1698.	-3.64	6
CRUISE PROP	38724.	2114.	37053.	2111.	-1671.	2.96	7
ORIENT SYS	4887.	2212.	5396.	2331.	509.	.31	8
SURF CONTROL	6926.	3721.	11320.	3851.	4394.	7.38	9
PRIME POWER	1723.	3710.	3582.	3654.	1859.	1.59	10
ELEC CON/DIS	1363.	2609.	1818.	2299.	455.	-1.48	11
HYDRAULICS	6043.	3700.	7282.	3700.	1239.	1.28	12
AVIONICS	3704.	1369.	4941.	1838.	1237.	.24	13
LAUNCH ESC	0.	0.	0.	0.	0.	-.00	
ECLS	4643.	2756.	2058.	2352.	-2585.	.29	14
PERS PROV	290.	1120.	288.	1120.	-2.	.01	15
BALLAST	0.	0.	0.	0.	0.	-.00	
PEND CHNGS	0.	0.	0.	0.	0.	-.00	
GROWTH	24248.	3059.	42009.	3095.	17761.	.19	16
DRY WT	541815.	3138.	575526.	3164.	33711.	26.00	
PERSONNEL	400.	1110.	522.	1110.	122.	-.44	17

TABLE 2.3-2 MP-10 TO DETAILED REPORT (Cont.)
MASS PROPERTIES CHANGE SUMMARY

CONFIGURATION: CANARD BOOSTER EASTERLY MISSION DATE:06/16/71

SUBSYSTEM	LAST REPORT 04/21		CURRENT REPORT 06/14		CHANGE		NOTE NO.*
	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G. IN.	WEIGHT LB.	X C.G.** IN.	
RESIDUALS	9547.	2373.	14707.	2837.	5160.	5.10	18
RESERVE	10441.	3768.	10245.	3801.	-196.	.38	19
LANDING WT	562203.	3135.	601000.	3165.	38797.	30.00	
CRU RESR DMP	36000.	3845.	34000.	3845.	-2000.	-2.24	20
END OF CRUSE	598203.	3178.	635000.	3201.	36797.	23.00	
CRU PRO USED	100000.	2050.	87000.	2257.	-13000.	44.52	21
APU PROP	1089.	2023.	2035.	2023.	946.	-1.34	22
CRUISE START	699292.	3015.	724035.	3084.	24743.	69.00	
INFLT LOSS	20788.	3276.	20812.	3313.	24.	1.08	23
ORIENT PROP	1200.	2023.	1212.	2023.	12.	-.02	24
PEND CHNGS	0.	0.	0.	0.	0.	-.00	
BURN OUT WT	721280.	3021.	746059.	3089.	24779.	68.00	
ASCENT PROP	758725.	2106.	759650.	2111.	925.	2.29	25
75% BURN	1480005.	2552.	1505709.	2596.	25704.	44.00	
ASCENT PROP	758725.	1938.	759650.	1938.	925.	-.17	26
50% BURN	2238730.	2344.	2265359.	2375.	26629.	31.00	
ASCENT PROP	758725.	1764.	759650.	1764.	925.	-.14	27
25% BURN	2997455.	2197.	3025009.	2222.	27554.	25.00	
ASCENT PROP	758725.	1571.	759650.	1605.	925.	6.75	28
LAUNCH WT	3756180.	2071.	3784659.	2098.	28479.	27.00	

* THESE NUMBERS CORRESPOND TO THE CHANGE ANALYSIS ITEM NUMBERS.
** THESE ARE CHANGES IN THE TOTAL VEHICLE C.G. CAUSED BY SYSTEM WEIGHT OR C.G. CHANGES.

TABLE 2.3-2 (Cont.)
MASS PROPERTIES CHANGE ANALYSIS

1. REFINED LOAD ANALYSIS (+542#). SUBSTITUTION OF 7075-T73 FOR 7075-T6 (+2150#). TRANSFER OF LEADING EDGE ABLATORS FROM THERMAL PROTECTION SYSTEMS (+667#). SUBSTITUTION OF METALLIC LEADING EDGE STRUCTURE FOR ABLATORS (+831#).

2. SUBSTITUTION OF 7075-T73 FOR 7075-T6 (+326#) INCREASE IN DORSAL FIN WEIGHT AND (+273#) INCREASE IN CANARD WEIGHT. TRANSFER OF DORSAL FIN LEADING EDGE ABLATORS FROM THERMAL PROTECTION SYSTEM (+228#). REDUCTION IN LEADING EDGE TPS AREA (DORSAL) AND SUBSTITUTION OF METALLIC LEADING EDGE STRUCTURE FOR ABLATORS (+234#) TRANSFER OF CANARD LEADING EDGE TPS FROM THERMAL PROTECTION SYSTEM (+377#). SUBSTITUTION OF HASTELLOY FOR COLUMBIUM FOR CANARD LEADING EDGE TPS (-39#). REFINED ANALYSIS OF CANARD LOADS (+243#). ADDITION OF VENTRAL FINS (+5730#). CONSERVATISM IN MP-10 WEIGHT ESTIMATE FOR INCORPORATING G.E. ENGINES (-1160#).

3. TRANSFERRED ORBITER ATTACH AND SEPARATION PROVISIONS TO LANDING & DOCKING(-3295#). REDESIGNED AFT SKIRT & THRUST STRUCTURE TO REFLECT CHANGE IN ASCENT ENGINE SPACING FROM 112 INCHES TO 106 INCHES (-1016#). DELETED THRUST STRUCTURE CONTINGENCY. CONTINGENCY IS ASSUMED TO BE ACCOUNTED FOR BY POSITIVE MARGINS IN STRUCTURAL MEMBERS (-3881#). REDESIGN OF LANDING GEAR PICK-UP ELIMINATING THE CENTER TRUSS AND TORQUE BOX PANELS AND INTEGRATING THE AFT TRUSS INTO THE EXISTING FRAME AT STA. 3710 (-3377#). REDESIGNED LH2 TANK TO REFLECT FINAL LOAD ANALYSIS (+1545#). ADDITION OF SUMP TO LH2 TANK AFT BLKHEAD (+526#). ADJUSTMENT TO LH2 TANK CONTINGENCY COMMENSURATE WITH THE CURRENT TANK WEIGHT (+129#). REDESIGNED LOX TANK TO REFLECT FINAL LOADS ANALYSIS (+367#). ADDITION OF SUMP TO LOX TANK AFT BULKHEAD (+335#). ADJUSTMENT OF LOX TANK CONTINGENCY COMMENSURATE WITH THE CURRENT TANK WEIGHT (+59#). REVISION OF COCKPIT ENCLOSURE WEIGHT TO REFLECT THE UNIT WEIGHT OF THE DC-10 ENCLOSURE. WEIGHT WAS PREVIOUSLY BASED ON THE UNIT WEIGHT OF THE DC-8 ENCLOSURE (-130#). INCORPORATION OF CURRENT DESIGN CONCEPT FOR WINDSHIELD THERMAL PROTECTION (+202#). MODIFICATION OF INTERTANK SIDEWALL WEIGHT TO AGREE WITH FINAL LOADS ANALYSIS(-32#). INCREASED INTERTANK CONTINGENCY ALLOWANCE (+127#). MISCELLANEOUS CHANGES (-59#).

4. LIMITING OF HCF THICKNESS INCREMENTS

TABLE 2.3-2 (Cont.)
MASS PROPERTIES CHANGE ANALYSIS

TO .05 INCHES (+1150#). ADDITION OF COATING TO EDGES OF HCF TILES (+2240#), BEEF-UP FOR PRESSURE INCREASE DUE TO INTERFERENCE (+360#). ADDITIONAL TPS FOR VENTRAL FINS (+3175#). REDESIGN OF RAILS, JOINTS, AND EDGING (+1430#). ADDITION OF SCRIMP CLOTH TO SUB-PANELS (+480#). RE-EVALUATION OF BASE HEAT PROTECTION (+50#). ADDITIONAL HCF FOR INCREASES IN ASCENT HEATING (+2356#). INCREASE IN SUB-STRATE WEIGHT TO REFLECTED REVISED PRESSURE PROFILE (+1710#). ADDITION OF STAND-OFFS TO ACCOMMODATE TUNNELS, FILLETS, AND FAIRINGS (+3327#). TRANSFER OF WING, TAIL, AND CANARD LEADING EDGE TPS TO STRUCTURE (-1272#). DELETION OF CONTINGENCY ALLOWANCE, WARRANTED BY DEPTH OF ANALYSIS (-6980#).

5. REFINED LANDING GEAR ANALYSIS (-1010#). TRANSFER OF ORBITER ATTACH AND SEPARATION SYSTEM FROM BODY STRUCTURE (+3295#).

6. ADDITION OF TPS ATTACH FLANGE TO ICD ENGINE WEIGHT (+660#). RE-EVALUATION OF PROPELLANT SYSTEMS REFLECTING LATEST CRITERIA (LOAD FACTORS) AND COMPONENT WEIGHTS (VALVES & BELLOWS) AND INCORPORATING ALUMINUM FOR PORTIONS OF THE MAIN LOX FEEDLINES (+1090#). REDUCTION IN PNEUMATIC SYSTEM REQUIREMENTS (-1627#). TRANSFER OF TVC HYDRAULIC FLUID TO RESIDUALS (-778#). REEVALUATION OF TVC REQUIREMENTS (-574#). TRANSFER OF CHILL-DOWN PROPELLANTS TO INFLIGHT LOSSES (-380#). RE-ANALYSIS OF CHILL-DOWN SYSTEM (-113#). ADDITION OF HYDRAULIC ENGINE CONTROL (+24#).

7. UTILIZATION OF CARTRIDGE STARTERS ON ALL ENGINES (+255#). PREVIOUS DESIGN USED BLEED AIR FOR STARTING 5 OF THE 10 ENGINES. RE-EVALUATION OF ENGINE INSTALLATION PENALTY RESULTING IN A CHANGE OF (-232#) IN THE AIR INDUCTION SYSTEM,(-105#) IN ENGINE MOUNT WEIGHT, (+220#) IN FIREWALL WEIGHT, AND (+905#) IN EXHAUST SYSTEM. DELETION OF CONTINGENCY ON ENGINE WEIGHT (-2528#). REDUCED CAPACITY OF FWD CRUISE TANKS (-186#). 77000 POUND CAPACITY WAS 100,000 POUNDS.

8. REDUCTION IN TANK WEIGHT RESULTING FROM INCORPORATION OF DUAL MODE APU (-203#). NOTE - ACPS AND APU SHOW COMMON LO2/LH2 TANKAGE. INCREASE IN ACCUMULATOR WEIGHT RESULTING FROM REFINED ANALYSIS AND INCREASE IN PRESSURE FROM 1950 PSIA TO 2140 PSIA (+160#).

TABLE 2.3-2 (Cont.)

MASS PROPERTIES CHANGE ANALYSIS

INCREASE IN LINE WEIGHT RESULTING FROM REFINED ANALYSIS AND ADDITION OF VACUUM JACKETS (+131#). WEIGHT INCREASE FROM REFINED VALVE INVENTORY AND ANALYSIS (+141#). INCREASE IN SUPPORT WEIGHT COMMENSURATE WITH SYSTEM GROWTH (+42#). ADDITION OF ACPS INSTRUMENTATION (+238#).

9. INCREASED HINGE MOMENTS & RATES RESULTING IN (+5159#) INCREASE IN HARDWARE AND A (+519#) INCREASE IN HYDRAULIC FLUID. TRANSFER OF HYDRAULIC FLUID TO RESIDUALS (-1100#). REDUCTION IN CONTROL WIRING RUNS (-184#).

10. INCORPORATION OF A DUAL MODE APU SYSTEM. DELETION OF HYDROGEN/OXYGEN POWER UNITS (-163#). ADDITION OF AIR-BREATHING POWER UNITS,BATTERIES, AND SUPPORTS (+2022#). WEIGHT INCREASE IS DUE TO INCREASED POWER REQUIREMENTS.

11. ADDITION OF LANDING, RUNNING, AND ANTI-COLLISION LIGHTS (+126#). ADDITION OF CONTROL/DISTRIBUTION INSTRUMENTATION (+6#). ADDITION OF REMOTE POWER CONTROLLERS (+420#) REFINED ANALYSIS OF CIRCUITRY AND EQUIPMENT WEIGHTS (-97#).

12. INCREASED POWER DEMAND COMMENSURATE WITH INCREASED SURFACE CONTROL REQUIREMENTS RESULTING IN A (+2746#) INCREASE IN HYDRAULIC SYSTEM HARDWARE AND (+1801#) INCREASE IN HYDRAULIC FLUID. TRANSFER OF HYDRAULIC FLUID TO RESIDUALS (-3308#).

13. ADDITION OF MAINTAINENCE RECORDER (+100#). ADDITION OF ACTUATOR ASSEMBLY FOR PITOT STATIC/ANGLE OF ATTACK SENSORS (+227#). SYSTEM UPDATE AND RE-EVALUATION (+910#).

14. MODIFICATION OF THERMAL CONTROL SYSTEM WEIGHTS TO AGREE WITH FINAL SCHEMATIC (+54#). INCORPORATION OF INITIAL DESIGN OF PURGE SYSTEM (-2826#). ADDITION OF TEN PERCENT CONTINGENCY ALLOWANCE (+187#).

15. REPLACEMENT OF RELIEF TUBE WITH URINE COLLECTION BAG (-2#).

16. ADJUSTED TO MAINTAIN BURNOUT WEIGHT REQUIRED FOR REFERENCE

Table 2.3-2 (Cont.)
MASS PROPERTIES CHANGE ANALYSIS

MISSION AND PAYLOAD (65K/DUE EAST). CURRENTLY 10.1% OF DRY WEIGHT LESS CRUISE AND ASCENT ENGINES (+17761#).

17. CREW AND EQUIPMENT WEIGHTS REVISED TO COMPLY WITH NASA LETTER MSC-CF31:71L:02 (+122#).

18. HYDRAULIC FLUID TRANSFERRED FROM HYDRAULIC, SURFACE CONTROL AND TVC SYSTEMS (+5186#). REDUCTION IN CRUISE RESIDUAL COMMENSURATE WITH REDUCTION IN CRUISE PROPELLANT (-300#). ADDITION OF ENGINE CONTROL AND GEAR HYDRAULIC FLUID (+195#). MISCELLANEOUS REVISIONS (+79#).

19. REDUCTION IN APU/ACPS RESERVES, IS 10% ON APU AND 5% ON ACPS, WAS 25% ON BOTH(-196#).

20. AND 21. REDUCTION IN CRUISE PROPELLANT REFLECTING LATEST SFC, RANGE, AND DRAG INFORMATION (-15000#).

22. INCREASE REFLECTING LATEST POWER REQUIREMENTS AND ADOPTIONS OF A DUAL MODE APU SYSTEM (+946#).

23. RE-DESIGN OF LO2 TANK SUMP RESULTING IN REDUCTION IN PULL-THROUGH (-1200#). ADDITION OF SHUTDOWN LOSSES (+852#). TRANSFER OF CHILL-DOWN PROPELLANTS FROM ASCENT PROPULSION (+380#). MISCELLANEOUS REVISIONS AND UPDATE (-8#).

24. UPDATE TO REFLECT LATEST REQUIREMENTS (+12#).

25. THRU 28. REVISED MAIN ASCENT PROPELLANT TO REFLECT MISSION REQUIREMENTS (+3700#).

3.0 Combined Configuration - The "combined configuration" data shown in this section is for the "analysis vehicle", i.e., the pending changes shown in Table 1-2 are not included. Data for the "final design baseline",which includes these changes, is presented in Report E0403.

Figure 3-1 shows the combined configuration launch arrangement. The coordinate axes system used for the combined configuration is also shown. This is the same system used for the Booster.

Weight, center of gravity coordinates on moments of inertia at various mission points are shown in Figure 3-2. Additional details to support these sequenced mass properties, including a description of the items jettisoned between mission points, is presented in Table 3-1.

The data shown in this section is for the Easterly mission. Similar data for the Resupply and Polar missions is presented in Appendix B.

FIGURE 3-1 CONFIGURATION/COORDINATE AXES

CONFIGURATION | LAUNCH ARRANGEMENT | DATE 15 JUNE 1971

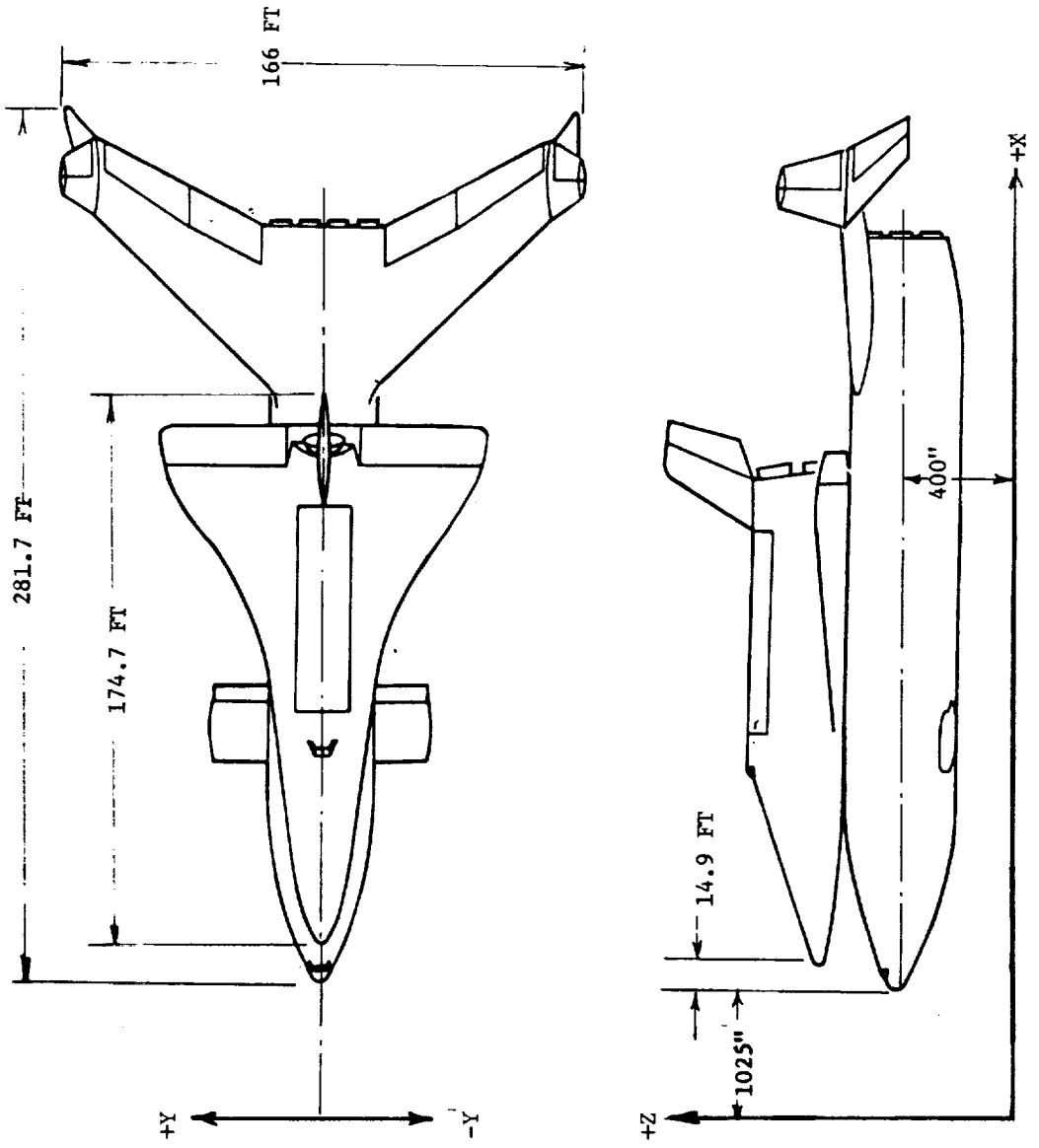
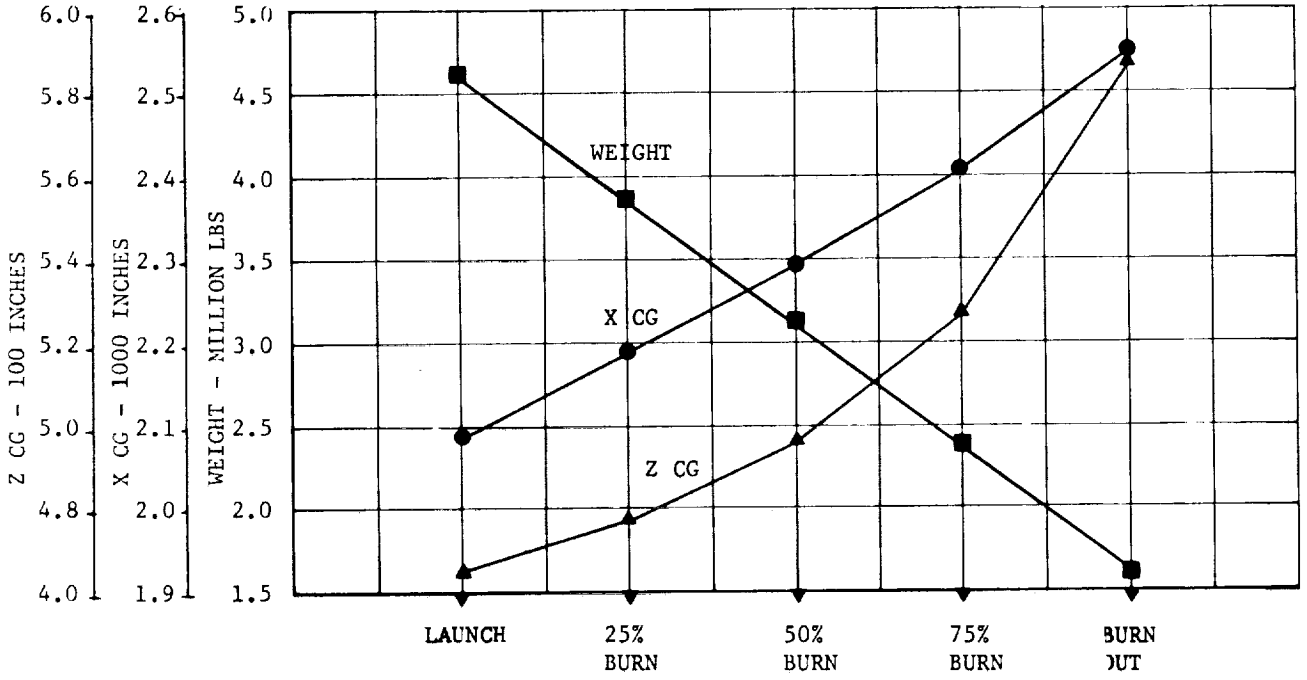


FIGURE 3-2 WEIGHT, CG'S AND MOMENTS OF INERTIA VS MISSION POINT (COMBINED CONFIGURATION)



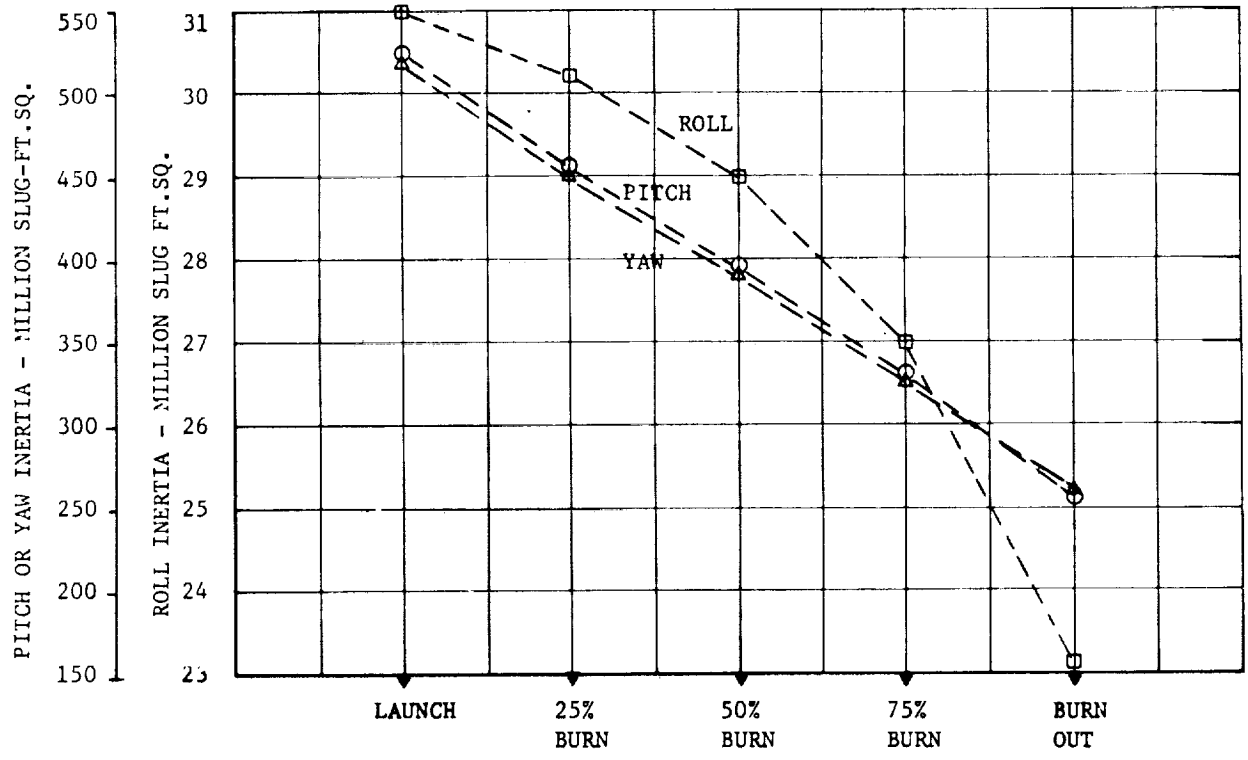


TABLE 3-1 SEQUENCED MASS PROPERTIES SUMMARY 06/12/71
65K EASTERLY MISSION
COMBINED CONFIGURATION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
		(INCH)			PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	860442.	2088.	0.	720.	2586.	41203.	42434.
					-14.	1.	2047.
BOOSTER BO	746059.	3089.	0.	433.	13414.	120605.	128073.
					-48.	3.	7201.
BURN OUT WT	1606501.	2553.	0.	587.	23116.	256028.	256912.
					-35.	-4.	-14847.
ASCENT PROP	759650.	2111.	0.	400.	0.	49800.	49800.
					0.	0.	0.
75% BURN	2366151.	2411.	0.	527.	20092.	331425.	328432.
					-28.	-1.	-5671.
ASCENT PROP	759650.	1038.	0.	400.	0.	36507.	36507.
					0.	0.	0.
50% BURN	3125801.	2236.	0.	496.	28085.	397730.	392745.
					-22.	1.	1772.
ASCENT PROP	759650.	1764.	0.	400.	0.	23195.	23195.
					0.	0.	0.
25% BURN	3885451.	2192.	0.	477.	30198.	459435.	453236.
					-16.	2.	8499.
ASCENT PROP	759650.	1605.	0.	400.	-0.	17496.	17496.
					0.	0.	0.
LAUNCH WT	4645101.	2036.	0.	465.	31014.	525078.	518062.
					-11.	2.	14715.

4.0 Orbiter Summary - The Delta Wing Orbiter data shown in this section and throughout the Detailed Mass Properties Report is for the "analysis vehicle", i.e., the pending changes shown in Table 1-2 are not included. Data for the "final design baseline",which includes these pending changes, is presented in Report E0403.

In Table 4-1 Orbiter weight summaries are shown at key mission points from main engine ignition thru landing. The total Orbiter weight at each mission point, as well as the center of gravity coordinates and moments of inertia, are shown graphically in Figure 4-1.

Table 4-2 is a six page Group Weight Statement which follows the format prescribed for the Space Shuttle program. Figure 4-2 shows the Delta Wing Orbiter configuration and describes the Orbiter coordinate axes system used throughout this report. Key design data is presented in Table 4-3.

Additional detail to support the sequenced mass properties shown in Figure 4-1, including a summaries of items jettisoned between mission points, is presented in Table 4-4.

Figure 4-3 is a general arrangement drawing for the Delta Wing Orbiter.

All the data shown in this section is for the Easterly mission. Similar data for the Resupply and Polar missions is presented in Appendix B.

TABLE 4-1 MISSION WEIGHT SUMMARY (EASTERLY)

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

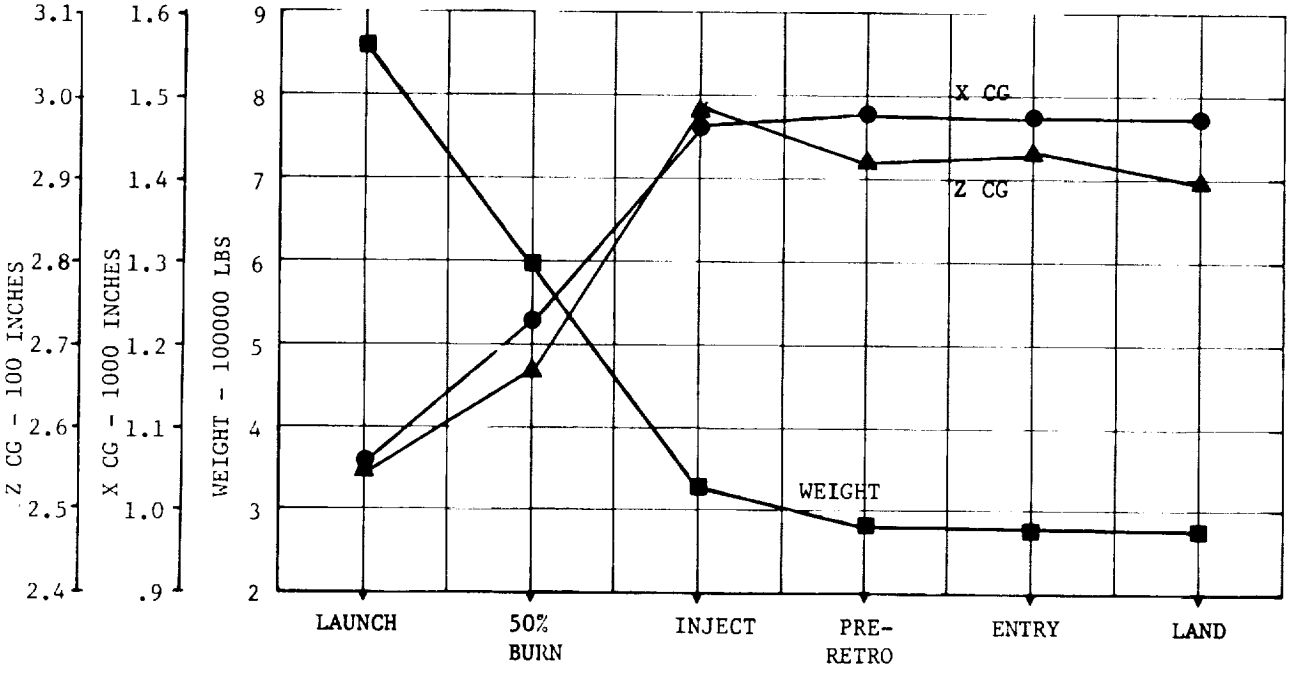
CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	31587							
2	TAIL GROUP	5104							
3	BODY GROUP	55500							
4	INDUCED ENVIR PROTECTION	32847							
5	LANDING, RECOVERY, DOCKING	10551							
6	PROPULSION-ASCENT	26637							
7	PROPULSION-CRUISE	574							
8	PROPULSION-AUXILIARY	11877							
9	PRIME POWER	2272							
10	ELECT CONVER & DISTR	1303							
11	HYDRA CONVER & DISTR	2760							
12	SURFACE CONTROLS	4901							
13	AVIONICS	4588							
14	ENVIRONMENTAL CONTROL	7849							
15	PERSONNEL PROVISIONS	430							
16	RANGE SAFETY & ABORT	0							
17	BALLAST	0							
18	GROWTH UNCERTAINTY	25363							
19									
	SUBTOTAL DRY WEIGHT	224143							
20	PERSONNEL	626							
21	CARGO	65000	65000	65000	65000	65000	40000	40000	40000
22	ORDNANCE	0							
23	RESIDUAL FLUIDS	4001							
24									
	SUBTOTAL INERT WEIGHT	293770	293770	293770	293770	293770	268770	268770	268770
25	RESERVE FLUIDS	13118	13118	13118	13118	6651	6651	6651	6651
26	IN FLIGHT LOSSES	9788	7826	7816	7383	3250	871	871	0
27	PROPELLANT-ASCENT	526257	526257	263128	0	0	0	0	0
28	PROPELLANT-CRUISE	0	0	0	0	0	0	0	0
29	PROPELLANT-MANEUV ACS	17510	17510	17510	17510	15517	6536	1000	0
30									
	TOTAL GROSS-WEIGHT LB	860443	858481	595342	331781	319188	282828	277292	275421

DESIGNATORS:

EVENTS
A LAUNCH
B IGNITION (EFFECTIVE)
C 50% BURN
D INJECTION
E ON-ORBIT
F PRE-RETRO
G ENTRY
H LANDING

NOTES & SKETCHES:

FIGURE 4-1 WEIGHT, C.G.'s AND MOMENTS OF INERTIA VS MISSION POINT (DELTA ORBITER)



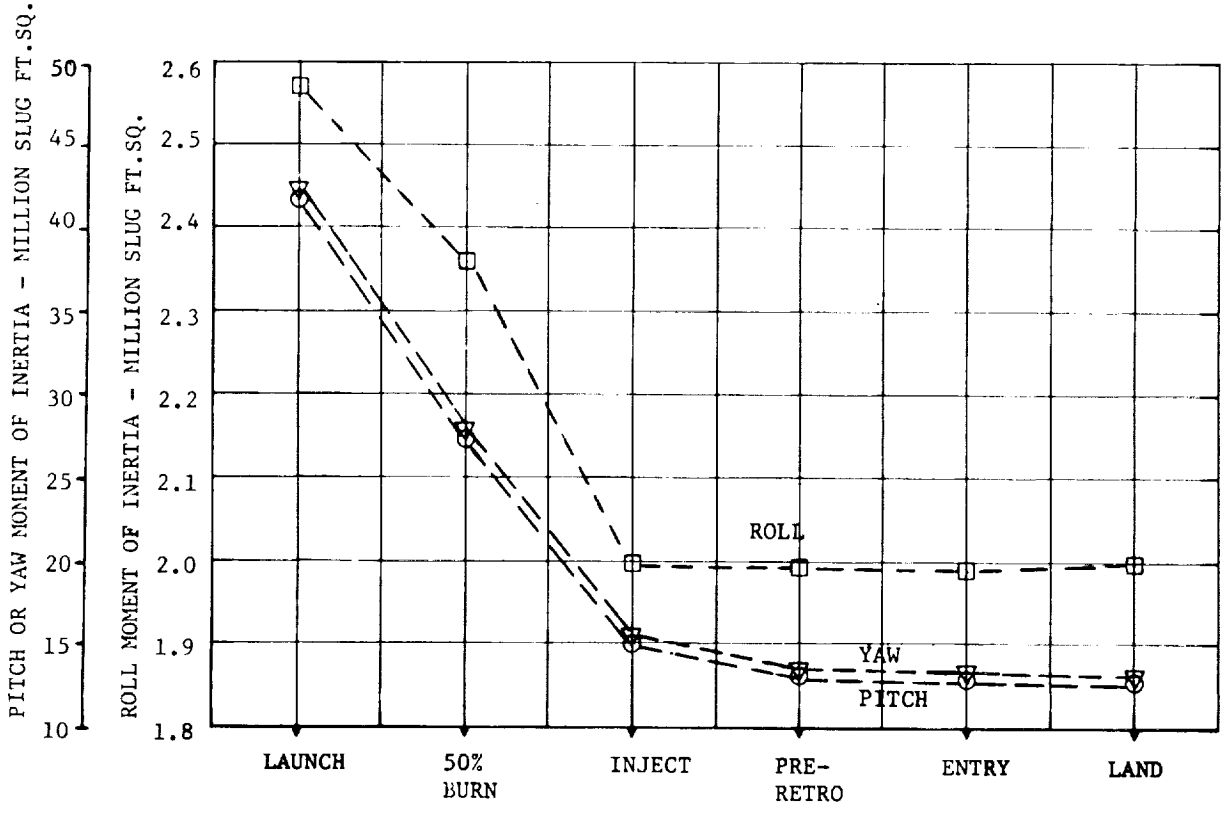


TABLE 4-2	GROUP WEIGHT STATEMENT (EASTERLY)			PAGE 1 OF 6	
CONFIGURATION	DELTA ORBITER	BY		DATE	15 June

1. WING GROUP		CARRY THROUGH	EXPOSED SURFACE		31587
		(2735)	(20060)		
BASIC STRUCTURE		2735	14788		
TORQUE BOX			5272		
LEADING EDGE			Inc'l		
TRAILING EDGE				2286	
SECONDARY STRUCTURE			518		
MAIN GEAR DOOR PROVISIONS			1768		
ABES DOOR PROVISIONS		SURFACE	SUPT/MECH	3634	
CONTROL SURFACES		3634			
ELEVON					
				2872	
CONTINGENCY					
2. TAIL GROUP		VERTICAL	HORIZ		5104
		(3380)	( )	3380	
BASIC STRUCTURE		2649			
TORQUE BOX					
CARRY THROUGH		731			
LEADING EDGE		N/A			
TRAILING EDGE		N/A			
SECONDARY STRUCTURE		SURFACE	SUPT. MECH	1260	
CONTROL SURFACES		1260	Inc'l		
RUDDER (INCL. BAL WT _____ LB)					
				464	
CONTINGENCY					55500
3. BODY GROUP				20648	
INTEGRAL TANKAGE					
FUEL TANK			9734		
OXIDIZER TANK			6042		
BETWEEN TANKS (CMN BLKHD)			2876		
INSULATION			1996		
BASIC STRUCTURE	FWD.	CTR,	AFT,	SKIRT	
	(5292)	(9548)	( )	(6984)	21824
SIDEWALLS	1928	2566		2105	
BULKHEADS	2664	5928		3609	
LONGERONS	700	1054		Inc'l	
THRUST STRUCTURE (MAIN ASCENT ENGINE)				1270	
SECONDARY STRUCTURE					7982
CREW COMPARTMENT				1799	
EQUIPMENT COMPARTMENTS				631	
SPEED BRAKES				534	
ENGINE HEAT PROTECTION				*	
INTERSTAGE (INCL. MECH. _____ LBS)				1370	
DOORS FAIRINGS				3318	
NOSE GEAR PROVISIONS				330	
					5046
CONTINGENCY					

TABLE 4-2 GROUP WEIGHT STATEMENT (EASTERLY) — PAGE 2 OF 6

CONFIGURATION: DELTA ORBITER — BY: — DATE: 15 June 1971

32847

	WING	HOR. TAIL	VER. TAIL	BODY	
4. INDUCED ENVIRONMENT PROTECTION					
THERMAL PROTECTION					(29861)
LEADING EDGE/NOSE CAP*	(**)	(0)	(**)	(350)	350
Carbon-Carbon				350	
SURFACE PROTECTION*	(8330)	(752)	(N/A)	(18543)	27625
Cb	2211			4545	
Hastelloy	3713	518		3809	
Rene 41				1244	
Inconel				1007	
Titanium				1046	
Insulation & Bagging	2406	234		6892	
BASE HEAT PROTECTION*				(1886)	1886
Insulation & Bagging				1886	
SOUND PROTECTION					( )
METEORITE 'RADIATION PROTECTION					( )
CONTINGENCY					(2986)

*BREAK OUT BY TYPE OF MATERIAL

** WEIGHT CARRIED WITH WING GROUP OR TAIL GROUP.

TABLE 4-2 GROUP WEIGHT STATEMENT (EASTERLY) PAGE 3 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June

5. LANDING, DOCKING						10551
ALIGHTING GEAR	ROLLING	STRUCTURE	CONTROLS	7600		
MAIN	3121	2660	843			
NOSE	176	563	237			
DOCKING				400		
AUXILIARY SYSTEMS				1763		
DECELERATION CHUTES			258			
INTERSTAGE ATTACH			627			
PAYLOAD HANDLING/TUNNEL			505/373			
CONTINGENCY				788		
6. PROPULSION – MAIN ASCENT						26637
ENGINE & ACCESSORIES				19422		
ENGINE (AS SUPPLIED)			17620			
GIMBAL SYSTEM			709			
IGNITION AND CONTROL SYSTEM			833			
PROPELLANT UTILIZATION SY			260			
ACCESSORIES			N/A			
INSTALLATION, DUCTS, SHROUDS				N/A		
PROPELLANT SY		FUEL	OXIDIZER	6206		
FILL DRAIN		170	120			
PRESSURIZATION /VENT		1242	616			
RECIRCULATION		93	90			
PCV SY		0	0			
PRE-VALVES		334	528			
FEED SYSTEMS		512	2059			
VORTEX, FLOW CONTROL SYSTEM		223	219			
TANKAGE – NONINTEGRAL	TANK	INSULATE	SUPTS		N/A	
FUEL	N/A	N/A	N/A			
OXIDIZER	N/A	N/A	N/A			
CONTINGENCY					1009	
7. PROPULSION – CRUISE BACK						574
ENGINE & ACCESSORIES					0	
ENGINE						
IGNITION AND CONTROL SY						
LUBRICATION SY (DRY)						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUD					0	
AIR INDUCTION						
ENGINE MOUNTING						
NACELLES PYLONS (INCL_____LB MECH)						
PROPELLANT SY					338	
FILL DRAIN			57			
PRESSURIZATION (DRY)			13			
VENT SY			10			
PUMP			N/A			
FEED SY			163			
TRANSFER SY			47			
DUMP SY			N/A			
SUPPORTS INSTALLATION			48			
TANKAGE – NON INTEGRAL	TANK	INSULATE	SUPTS		175	
FUEL	79	44	52			
CONTINGENCY					61	

TABLE 4-2 GROUP WEIGHT STATEMENT (EASTERLY) PAGE 4 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

8. PROPULSION – AUXILIARY				ATT. CONTROL		MANEU-VER	11877
THRUSTER INSTALLATION				1291		667	
THRUSTER			1038		607		
ACCESSORY			253		60		
PROPELLANT SY				3664		1112	
FILL 'DRAIN			423				
PRESSURIZATION			444				
VENT			150				
FEED SYSTEM			892		1112		
ACCUMULATORS			1062				
CONDITIONING EQUIPMENT			693				
TANKAGE				3935			
TANKS			1749				
INSULATION			1648				
SUPPORTS			538				
CONTINGENCY				1067		141	
9. PRIME POWER	POWER UNIT	MTG INSTAL	PROPEL TANK/SYS	TEMP CONTROL	CON-TROLS	TOTAL	2272
BATTERIES	N/A	N/A	N/A	N/A	N/A	(N/A)	
ENGINE TURBINE	368	245	N/A	264	48	(925)	
FUEL CELL	980	36	N/A	24	11	(1051)	
CONTINGENCY						(296)	
10. ELECTRICAL		SUPPLY	CONVER-SION	CONTROL UNITS		601	1303
EQUIPMENT		90	N/A	511			
DISTRIBUTION AND CONTROL CIRCUITRY						435	
UTILITY SYSTEMS						30	
SUPPORTS/INSTALLATION						24	
CONTINGENCY						213	
11. HYDRAULIC	SYSTEM	#1	#2	#3	#4		2760
		(512)	(512)	(512)	512	2048	
POWER SUPPLY		138	138	138	138	(552)	
DISTRIBUTION CONTROL CTR		176	176	176	176	(704)	
TEMPERATURE CONTROL SY		71	71	71	71	(284)	
AUXILIARY SYSTEMS		22	22	22	22	(88)	
SUPPORTS INSTALLATION		105	105	105	105	(420)	
CONTINGENCY						712	
12. SURFACE CONTROLS						(SEE AVIONICS)	4901
COCKPIT CONTROLS						(SEE AVIONICS)	
FLIGHT CONTROL SY		POWER		SEC-ONDARY	SUPTS		
SYSTEM ACTUATION	CONTROLS	XMISSION	ACTUATOR	ACT.	INSTALL.		
	(267)	(153)	(3446)	(130)	(424)	4420	
AILERON	N/A	N/A	N/A	N/A	N/A		
ELEVON	138	97	2068	52	227		
RUDDER	57	48	465	26	67		
T.E. FLAP	N/A	N/A	N/A	N/A	N/A		
SPEED BRAKE	72	8	913	52	130		
CONTINGENCY						481	
13. AVIONICS	UNITS	CIRCUITRY	COOLING	ANTENNAS	INSTALL.		4588
	(2430)	(652)	(N/A)	(83)	(824)		
GUID NAV	292	62	ECLS		162	516	
FLIGHT CONTROL	224	44	ECLS		59	327	
DATA MANAGEMENT	826	238	ECLS		138	1202	
COMMUNICATE	394	117	ECLS	83	335	929	
CONFIG. SEQ,	INCL IN	DATA MANAGEMENT					
INSTRUMENTATION	"	"	"				
DISPLAYS	694	191	ECLS		130	1015	
CONTINGENCY						599	

TABLE 4-2 GROUP WEIGHT STATEMENT (EASTERLY) PAGE 5 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

14. ENVIRONMENTAL CONTROL								7849
GAS SUPPLY SYSTEM (DRY)							166	
GAS MANAGEMENT, PROCESSING (DRY)							685	
HEAT TRANSPORT SYSTEM (DRY)							2009	
WATER MANAGEMENT SYSTEM (DRY)							345	
PURGE SYSTEM & FIRE EXTINGUISH							1119	
INSULATION							2877	
CONTINGENCY							648	
15. PERSONNEL PROVISIONS								430
SEATS 'RESTRAINT SYS (NO = 2)							159	
FIXED LIFE SUPPORT EQUIPMENT							130	
EMERGENCY EQUIPMENT							30	
CARGO HANDLING							--	
FURNISHINGS							91	
CONTINGENCY							20	
16. RANGE SAFETY AND ABORT								
17. BALLAST								
18. GROWTH/UNCERTAINTY								25363
19. OPEN								
SUBTOTAL (DRY WEIGHT)								(224143)
20. PERSONNEL	NO	MAN	GARMENTS	HELMET	PRESS. SUIT	ACCESSORIES		626
CREW	2	392	2	12	26	1	433	
PASSENGER ( )							78	
PERSONEL GEAR 'ACCESSORIES							115	
LIFE SUPPORT								
FOOD						59		
EQUIPMENT – PORTABLE						56		
21. CARGO								65000
22. ORDNANCE								
23. RESIDUAL & UNUSABLE FLUIDS								4001
ASCENT							737	
CRUISE							0	
MANEUVER							1430	
ATTITUDE CONTROL							INCL MANEU	
ECS							621	
EPS							0	
HYDRAULIC							1087	
MISC. (SHOCK STRUT, ETC.)							126	
24. OPEN								
SUBTOTAL (INERT WEIGHT)								(293770)

TABLE 4-2 GROUP WEIGHT STATEMENT (EASTERLY)				PAGE 6 OF 6
CONFIGURATION	DELTA ORBITER	BY	DATE	15 June 1971

	MANEUV.	ACS	
25. RESERVE FLUIDS			13118
ASCENT		6486	
CRUISE		0	
MANEUVER		4720	
ATTITUDE CONTROL		1662	
ECS		102	
EPS		0	
HYDRAULIC		148	
26. INFLIGHT LOSSES			9788
ASCENT		6467	
CRUISE		0	
MANEUVER		1552	
ATTITUDE CONTROL		Incl. Maneu	
ECS		324	
EPS		640	
HYDRAULIC		805	
27. PROPELLANT – ASCENT			526257
28. PROPELLANT – CRUISE			0
29. PROPELLANT – MANEUV ACS	15847	1663	17510
TOTAL (GROSS WEIGHT)			(860443)

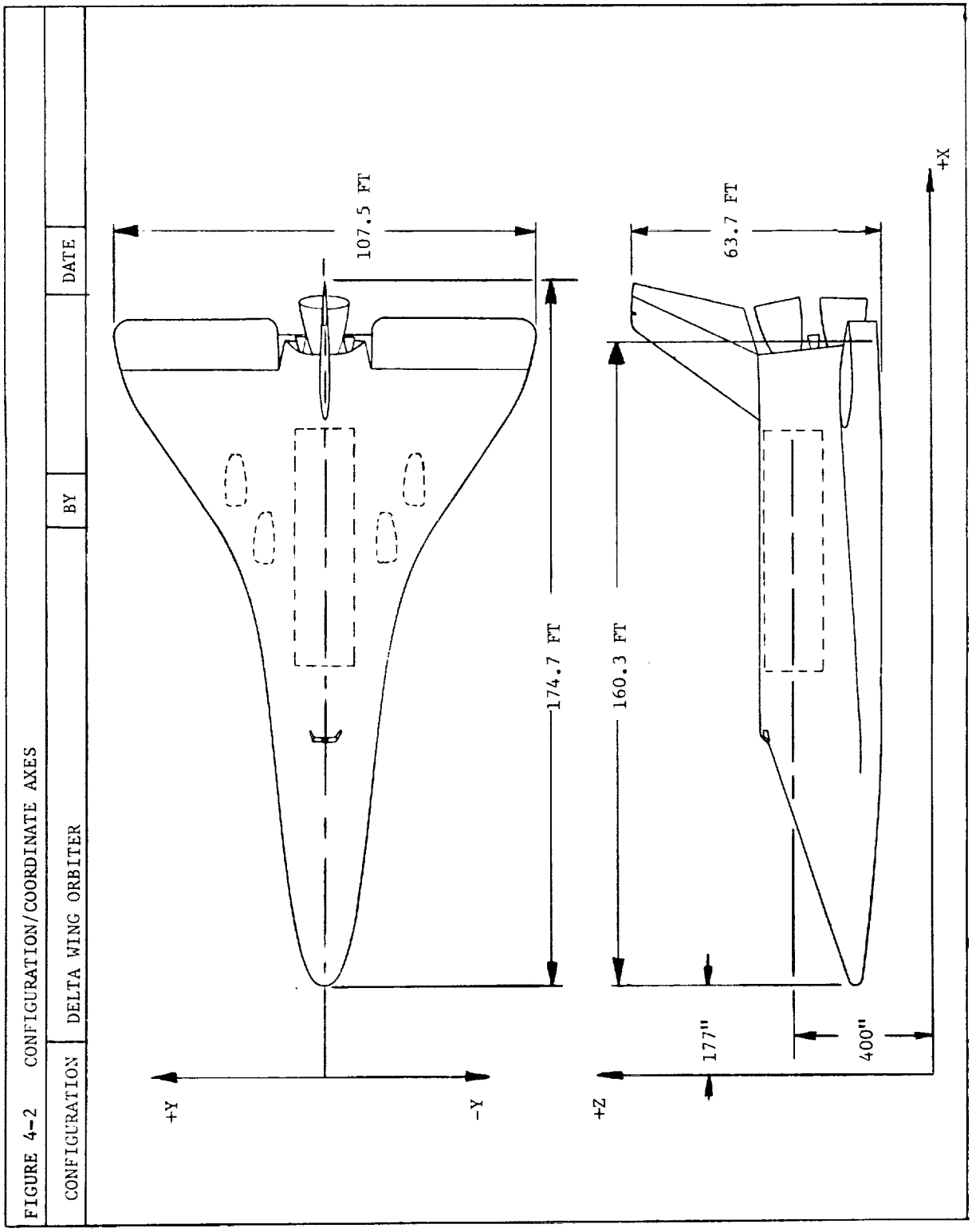


FIGURE 4-2 CONFIGURATION/COORDINATE AXES

TABLE 4-3 DESIGN DATA SUMMARY (EASTERLY)				PAGE 1 OF 8
CONFIGURATION	DELTA ORBITER	BY		DATE 15 June 197

MAX DYNAMIC PRESSURE, LB/SQ. FT. 730 ASCENT HEADWIND
MAX $q\alpha$ PSF DEGREE -1794 α WING
ENTRY VELOCITY FT/SEC 25655
ENTRY COEFFICIENT W/C_LS 110/54/110
ENTRY ANGLE DEGREES 25/46/25

ULTIMATE LOAD FACTOR	Nx	Ny	Nz	@	WEIGHT, LB
ASCENT	4.20	±.20	-.50		860,000
ABORT	--	--	--		860,000
SEPARATION	--	--	--		860,000
ENTRY	-.21	--	+2.9		267,500
CRUISE	--	--	+3.5		266,500
LANDING	--	--	+3.5		266,500

1. WING GROUP

	INSIDE FUSELAGE	EXPOSED	
GROSS AREA SQ FT	(2240*)	(3557)	5543
TORQUE BOX	502	2058	
LEADING EDGE (FIXED)		485**	
TRAILING EDGE (FIXED)		N/A	
MOVABLE SURFACES		1050***	
VOLUME – CU. FT			(SEE PARA. 4)

	MAC	ROOT THEORETICAL	BODY JUNCTION (B.L.167)	PLANFORM BREAK	TIP (B.L. 617)
CHORD LENGTH (FT)	61.69	90.29	70.42		16.875
CHORD THICKNESS (FT)		8.88	7.04		2.09
SPAN BETWEEN CHORDS (FT)			27.83	75.0	

DIHEDRAL ANGLE (DEG) 10 SPAN BETWEEN DIHEDRAL BASES FT 27.8
SWEEP BACK ANGLE (MEAN CHORD) 27.5 25% CHORD 47.5
AIRFOIL DESCRIPTION NACA 0010-64 @ Y167, NACA 0012.4 @ Y617
TAPER RATIO .186
THICKNESS CHORD: ROOT .0983 TIP .124
DESIGN LOAD 200300 lb (LIMIT PER EXPOSED SURFACE)
CRITICAL LOAD CONDITION AIRPLANE FLIGHT (+2.5G MANEUVER)

CONTROL SURFACES	TYPE	AREA – SQ FT RETRACT	EXTEND
ELEVONS		1050	1050
L. E. FLAPS		N/A	N/A
SPOILERS		N/A	N/A
SPEED BRAKES		N/A	N/A

PRIMARY STRUCTURAL MATERIALS

	MATERIAL	DESIGN TEMP °F
TORQUE BOX	TITANIUM	600
LEADING EDGE	C-C & Cb	2660 & 2060
TRAILING EDGE (FIXED)	N/A	N/A
MOVABLE SURFACES	TITANIUM	600

NOTES: * DIFFERENCE BETWEEN THEORETICAL AREA & TORQUE BOX AREA IS 1738 FT^2
** TIP RADIUS DECREASE OF 24 FT^2 AND STRAKE PLAN VIEW AREA 278 FT^2 IS INCLUDED IN EXPOSED AREA BUT NOT THE 5543 TOTAL WING THEORETICAL AREA.
*** ELEVON AREA INCLUDES 36 FT^2 INBOARD OF Y167 WHICH IS NOT IN ANY TOTAL.

TABLE 4-3 DESIGN DATA SUMMARY (EASTERLY MISSION)				PAGE 2 OF 8	
CONFIGURATION	DELTA ORBITER	BY		DATE	15 June 1971

2. TAIL GROUP	INBOARD VERTICAL	OUTBOARD VERTICAL	FWD HORIZONTAL	AFT	
EXPOSED AREA FT^2 (TOTAL)	( )	(592***)	( )	( )	
TORQUE BOX		264			( )
LEADING EDGE (FIXED)		105			( )
TRAILING EDGE (FIXED)		0			( )
MOVABLE SURFACES		223			( )
CARRY THROUGH AREA – FT^2		--			
EXPOSED SEMI-SPAN – FT		28.2			
CARRY THROUGH SPAN – FT		--			
NO. OF SURFACES VEHICLE		1			
VOLUME – CU FT		1015			
PRIMARY STRUCT.MATERIAL		INCONEL 718			
CHORD LENGTH					
ROOT (THEORETICAL) FT.		26.42			
MAC FT.		21.98			
BODY, JUNCTION		26.42			
TIP, FT.		16.83			
CHORD MAX. THICKNESS					
ROOT, FT		2.4			
TIP, FT		1.5			
DIHEDRAL ANGLE, DEGREE		0			
SWEEPBACK, 25% CHORD		26°			
CRITICAL LOAD CONDITION		ASCENT			

3. BODY GROUP	FWD BULKHEAD	BARREL	AFT BULKHEAD	COMMON BULKHEAD	
INTEGRAL TANK WETTED AREA – FT^2					
OXIDIZER TANK	120	2704			(2824)
FUEL TANK		4902	487		(5389)
INTER-TANK STRUCTURE				600	(600)
ULLAGE PRESSURE – PSI	OXIDIZER 30		FUEL 30		
	FS 177 to 1076	1076 to 1865		1865 to 2100	
BASIC STRUCTURE WETTED AREA – FT^2	FWD (4011)	CTR (5996)	AFT ( )	SKIRT (1255)	11262
SIDEWALLS	824	1674		Incl	
TANKAGE**	2480	2790		--	
NON STRUCTURAL*	707	1532		--	
THRUST STRUCTURE (MAIN ASCENT ENGINE)				1255	
BODY VOLUME – CU FT (TOTAL M.L.					(74701)
PRIMARY STRUCTURAL MATERIAL	ALUMINUM TANK		TITANIUM PANELS		

* CARGO DOOR, MAT'L ABOVE WL 425 BKHD.
** INCL FWD & AFT TANK EXTENSIONS
*** THEORETICAL AREA – 610 FT^2

TABLE 4-3 DESIGN DATA SUMMARY (EASTERLY)				PAGE 3 OF 8	
CONFIGURATION	DELTA ORBITER	BY		DATE	15 June 1971

3. BODY GROUP (CONTINUED)

MISCELLANEOUS	WETTED AREA-SQ.FT.	VOLUME CU. FT.	ULT DES. PRESS. DIFF. – PSI
CREW COMPARTMENT	615	878	
EQUIPMENT COMPARTMENT	Detail Definition on 2.14-33		
RADOME ANTENNAS	Incl in Avionics		
SPEED BRAKES	100	N/A	N/A
DOORS FAIRINGS	1532		
TANKS – OXIDIZER			
TANKS – FUEL			

4. INDUCED ENVIRONMENT PROTECTION

		WING	HOR.TAIL	VER.TAIL	BODY	
TOTAL VEH. WETTED AREA-FT^2		7549	454	1239	14154	(23396)
LEADING EDGE NOSE CAP AREA – SQ FT		(1161*)	(0)	(174*)	(70)	1405
MATERIAL	Carbon-Carbon	389		174	70	
MATERIAL	Cb L.E.	129				
MATERIAL	Cb Strake	643				
SURFACE PROT. AREA- SQ. FT.		(3246)	(320)	(0)	(12086)	15652
MATERIAL	Cb	937				
MATERIAL	Hastelloy	2309	320		1348	
MATERIAL	Rene 41				2354	
MATERIAL	Inconel				895	
MATERIAL	Titanium				746	
MATERIAL	Insulation & Bagging**				1341	
MATERIAL					5402	
MATERIAL						
UNPROTECTED AREA-SQ FT		(3142)	(134)	(1065)	(0)	4341
BASE: MATERIAL	Insulation & Bagging				(1998)	1998
TOTAL VEHICLE VOLUME – CU. FT. (OUTER MOLDLINE)		14200	125***	1015	74701	(90041)
VOLUME INSIDE PRIMARY STRUCTURE – CU FT		12316	55***	1015	65587	(78973)
TPS VOLUME CU FT		1884	70***	0	9114	(11068)
LEAD. EDGE NOSE CAP RAD-FT.		1.33 to .5	N/A	.24 to .15	1.83	
LEAD. EDGE NOSE CAP MAX TEMP °F		2660	N/A	3650	2340	
LOWER SURFACE MAX TEMP °F		1990	1890	N/A	2110 to 1810	
SIDE SURFACE MAX TEMP°F		N/A	N/A	1330	1360 to 600	
UPPER SURFACE MAX TEMP°F		600	N/A	N/A	600	

NOTES:

* WEIGHT IS CARRIED WITH WING OR TAIL GROUP
** IN ADDITION ALL METAL SHINGLE AREAS HAVE INSULATION BLANKETS.
*** VOLUME AFT OF X = 2100 ONLY.

TABLE 4-3 DESIGN DATA SUMMARY (EASTERLY) — PAGE 4 OF 8

CONFIGURATION: DELTA ORBITER — BY: — DATE: 15 June 1971

5. LANDING, RECOVERY, DOCKING

ALIGHTING GEAR	NO. VEH	DESIGN LOAD – LB	EXTENDED STRUT LGTH – FT	STROKE FT	PRIMARY MATL	BRAKE MATL
MAIN GEAR	2	334890	11.2	1.33	STL	CARBON
NOSE GEAR	1	106700	11.3	2.54	STL	N/A

MAX. DESIGN LANDING WT – LB. = 266488
LANDING SPEED – KNOTS = 180
ANGLE OF ATTACK @ LANDING – DEG = 12° MAX

LIMIT LANDING SINK SPEED
10 FT SEC @ 266488 LB. LANDING WEIGHT
10 FT SEC @ 266488 LB. MAX DESIGN LANDING WEIGHT

SEPARATION SYSTEM
DESIGN "q" @ SEPARATION – PSF =
MAX. AXIAL ACCELERATION – g's = 3.07 (LIMIT)
MAX. DESIGN SEPARATION – WT. LB. = 860000

DECELERATION CHUTE
DIAMETER – FT – 40. MAIN, 7. PILOT
NO VEH'CLE – 1 + 1

6. PROPULSION – MAIN ASCENT

	THRUST-SL	THRUST-VAC	EXP RATIO	I_{sp} VAC	CHAMB PRES PSI
ENGINE	550K	632K	150	459	3000

PROPELLANT SYSTEM	FUEL	OXIDIZER	(OPERATING LIMIT)
ULLAGE PRES. – PSI	30	30	
PROPEL TYPE	LH_2	LOX	
ULLAGE VOL – FT^3	538	189	(727)
PRESSURANT	GH_2	GOX	
TOTAL TANK VOL – FT^3 *	18524	6874	(25398)
USABLE PROP VOL – FT^3 **	17986	6685	(24671)
TOTAL LEN OF FEEDLINES – FT	27	195	

TANKAGE – NONINTEGRAL	NO.	SHAPE	WET AREA SQ FT	VOLUME CU FT
OXIDIZER	N/A	N/A	N/A	N/A
OXIDIZER				
OXIDIZER				
FUEL				
FUEL				
FUEL				

NOTES: * NET USABLE PLUS ULLAGE (INCLUDES FEED LINE AND ENGINE VOLUME)
** INCLUDES FEED LINE AND ENGINE VOLUME

TABLE 4-3	DESIGN DATA SUMMARY (EASTERLY)		PAGE 5 OF 8
CONFIGURATION	DELTA ORBITER	BY	DATE 15 June

7. PROPULSION – CRUISEBACK

NO. OF ENGINES
ENGINE THRUST – S.L. STATIC – LB
SPECIFIC FUEL CONSUMPTION LB/LB – THRUST PER HR
◦ NOMINAL CRUISE ALTITUDE – FT
NOMINAL CRUISE ALTITUDE – FT
NOMINAL CRUISE SPEED – KNOTS
CRUISE ALTITUDE ENGINE OUT – FT
CRUISE SPEED, ENGINE OUT – KNOTS
CRUISE RANGE (ACTUAL REQ) – NA MI
CRUISE RANGE (MAX AVAIL – NO HEADWIND, ALL ENGINES UP)
CRUISE LIFT DRAG RATIO
ENGINE THRUST SIZED BY
LIFT COEFFICIENT FOR CRITICAL THRUST CONDITION

	TYPE	TANK VOL CU FT	TANK MATL	TANK PRES-PSI	BURST FACTOR	NO. OF TANKS
FUEL SYSTEM	JP	80	AL	30	2	2
PRESSURIZATION SYSTEM	USES MAIN ASCENT PNEUMATIC SYSTEM				RESIDUAL GAS	

AIR INTAKE – LENGTH-FT.
– DIAMETER-FT
NACELLE WETTED AREA – EACH-SQ FT

8. PROPULSION – AUXILIARY

THRUSTERS

THRUST (VAC) – LB	I_{SP} – SEC	ACS	QUANTITY REQ MANEUVER	COMBIN	
15000	444	0	2	0	(2)
1600	379	0	2	0	(2)
1600	360/379	0	0	28	(28)
					( )
					( )

PROPELLANT SYS	TYPE	TANK** VOLUME	TANK MATL	TANK PRES.PSI	BURST FACTOR	NO. OF TANKS
FUEL	LH_2	2464 FT^3	AL	32	2	1
OXIDIZER	LOX	288.5 FT^3	Ea. AL	41	2	2
FUEL PRESSURANT	He	12.1 FT^3	AL	3000	2	1
OXIDIZER PRESS.						

** NET USABLE PLUS ULLAGE

9. PRIME POWER

	SPECIFIC POWER		TOTAL POWER/ ENERGY	TYPE
BATTERIES	N/A	WATT-HR/LB	N/A WATT-HRS	N/A
ENGINE TURBINE	*	HP-HR/LB FUEL	349 HP-HR	H_2-O_2
	2.87	HP/LB OF ENGINE (BASIC	320 HP (4 Req'd)	
FUEL CELL	935	WATT HRS/LB FUEL UNIT)	667K WATT-HRS	H_2-O_2
	28.6	WATTS/LB OF FUEL CELL	7K WATTS CONTINUOUS (4 REQ'D)	

TABLE 4-3	DESIGN DATA SUMMARY (EASTERLY)			PAGE 6 OF 8	
CONFIGURATION	DELTA ORBITER	BY		DATE	15 June 1971

10. ELECTRICAL POWER CONVERSION DISTRIBUTION

SYSTEM VOLTAGE = 120 VOLTS
PEAK POWER = 10.5K WATTS (FUEL CELL RATING IS 7KW CONTINUOUS & 14KW PEAK)
AVERAGE POWER = 4.07K WATTS 677 KWH/166 HRS

11. HYDRAULIC POWER CONVERSION DISTRIBUTION

SYSTEM NOMINAL OPER PRESSURE = 3000 PSI
PEAK POWER = 277 HORSEPOWER
AVERAGE POWER (EST. CONTINUOUS) = 40 HORSEPOWER
TOTAL VOLUME OF FLUID = 21 FT^3 1087 oLB/.03 LB/IN^3/1728 IN^3/FT^3
FLUID TYPE MIL-H-83282 MAX OPER TEMP - F 275

12. SURFACE CONTROLS *

SURFACE	AREA FT^2	MAX DEFL RATE DEG/SEC	MAX DEFL DEG	DESIGN HINGE MOM. IN-LB PER ACTUATOR	NO/ VEHICLE
ELEVON	525	35	65	3.06×10^6	2/6 Act's
RUDDER	223	30	60	1.3×10^6	1/2 Act's
SPEED BRAKE	65	25	60	1.4×10^6	2/4 Act's

*SEE MDAC MEMO NO. SSPI-E450-576 FOR LOADS DATA.

13. AVIONICS

14. ENVIRONMENTAL CONTROL

	SOURCE	TOT. STOR VOL-FT^3	STORAGE PRES.	TANK MATL	NO. OF TANKS
GAS SUPPLY SYSTEM		(6.5)			(3)
PRIMARY OXYGEN	OAMS	N/A	N/A	N/A	N/A
SECONDARY OXYGEN	ECLS	1.0	3000	COMP. FIBER	1
DILUENT-N_2	ECLS	5.5	3000	COMP. FIBER	2

GAS REQUIREMENT AVERAGE RATES
METABOLIC = 1.84 LB MAN-DAY
LEAKAGE = 3.5 LB DAY
REPRESSURIZE = 62.7 LB REPRESSURIZE (CABIN, AIRLOCK & EXT. TUNNEL)
PRESSURIZED SURFACE AREA - FT^2 405-CABIN, 210-AIRLOCK
HEAT TRANSPORT SYSTEM CAPACITY = 30,700 BTU/HR (PEAK) RADIATOR
** = 57,400 BTU HR (PEAK) TOTAL SYSTEM
RADIATOR AREA - 615(EFFECTIVE) SQ FT ALUM MATERIAL **PROJECTED AREA
CRYOGENIC HYDROGEN = 67×10^{-5} LB/BTU X 349.5 X 10^3 BTU'S = 234 LB LH_2
WATER MANAGEMENT SYSTEM CAPACITY

DRINKING WATER - *6.25 LB MAN-DAY x *28 MAN DAYS
WASHING - N/A LB MAN-DAY x N/A MAN DAYS
COOLING - N/A LB BTU x N/A BTU's

*PROVIDED NOMINALLY BY FUEL CELLS.

15. PERSONNEL PROVISIONS

16. RANGE SAFETY AND ABORT

TABLE 4-3	DESIGN DATA SUMMARY (EASTERLY)			PAGE 7 OF 8	
CONFIGURATION	DELTA ORBITER	BY		DATE	15 June 1971

17. BALLAST
DESIGN C.G. ENVELOPE FWD - 66.1 %L AFT - 68.5 %L
NOMINAL C.G. WITHOUT BALLAST - _____ %L
NOMINAL C.G. WITH _____ LB BALLAST - _____ %L
MAX DESIGN LANDING WT-LB _____ @ _____ % MAC. C.G.

18. GROWTH UNCERTAINTY

CURRENT ALLOWANCE - 25363 LB
CONTRACTORS EST OF ALLOWANCE NEEDED TO GUARANTEE
CURRENT PAYLOAD AND GROSS WT - 18116 LB*
REMAINING GROWTH ALLOWANCE FOR
CUSTOMER CHANGES - 7247 LB

* FOR SYSTEM REQUIREMENTS AS DEFINED BY 10% Less Ascent Engines

19. OPEN

20. PERSONNEL
NO. OF CREW - 2 ; AVE PERCENTILE MAN - 90
NO. OF PERSONNEL TOTAL _____ ; AVE PERCENTILE MAN - _____

21. CARGO CARGO BAY VOLUME - 10603 CU FT
BAY DIA - 15 FT CLEAR
BAY LGTH 60 FT CLEAR

22. ORDNANCE

23. RESIDUAL FLUIDS - DEFINE WEIGHT ESTIMATING RATIONALE

24. OPEN

25. RESERVE FLUIDS

26. INFLIGHT LOSSES

TABLE 4-3 DESIGN DATA SUMMARY (EASTERLY) PAGE 8 OF 8

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

27 – 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO (BY WEIGHT)	6	N/A	5 & 3.53	5 & 3.53
OXIDIZER ULLAGE VOLUME – PERCENT*	5.5**		47.2	47.2
FUEL ULLAGE VOLUME – PERCENT*	5.5**		34.0	34.0
FUEL DENSITY – PCF	4.395		4.37	4.37
OXIDIZER DENSITY – PCF	71.0		70.6	70.6
FUEL BIAS – PERCENT	.25			
INCREMENTAL VELOCITY – FPS	(14322)		900	N/A
INERTIAL	13736			
ANGLE OF ATTACK	53			
GRAVITY LOSSES	212			
DRAG LOSSES	2			
BACK PRESSURE LOSSES	29			
FLT. PERFORMANCE RESERVE	290			
RANGE – NA MI		( )		
GROUND MILES				
HEAD WIND ALLOW.				
CONTINGENCY				
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING GO-AROUND–MINUTES				

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES.

** 3% PLUS 1% LOAD ALLOWANCE FOR MIN. I_{SP} LOADING.

TABLE 4-4 SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
65K EASTERLY MISSION
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	31587.	1738.	0.	194.	549.	423.	962.
					0.	0.	4.
TAILS	5104.	2054.	0.	632.	2.	11.	11.
					0.	0.	2.
BODY	55500.	1292.	0.	291.	191.	2605.	2551.
					0.	0.	82.
THERMAL PROT	32847.	1353.	-0.	191.	388.	2734.	3095.
					-0.	-0.	-6.
LANDING/DOCK	10551.	1438.	-0.	129.	102.	432.	452.
					-0.	-0.	-36.
PROP-ASCENT	26637.	1863.	4.	320.	42.	416.	395.
					-3.	-1.	3.
PROP-CRUISE	574.	1542.	25.	288.	3.	2.	4.
					0.	-0.	-0.
PROP-AUXIL	11877.	1291.	6.	320.	31.	677.	691.
					-0.	1.	-28.
PRIME POWER	2272.	1015.	-31.	258.	1.	264.	265.
					-12.	-0.	0.
ELEC DIST	1303.	832.	-16.	235.	0.	48.	48.
					-2.	-0.	2.
HYDRA DIST	2760.	1705.	-52.	262.	5.	42.	45.
					-2.	-0.	3.
SURF CONTROL	4901.	1944.	0.	308.	92.	33.	71.
					0.	0.	7.
AVIONICS	4588.	1030.	1.	384.	12.	101.	99.
					1.	-0.	-5.
ENVIR CONTRL	7849.	1124.	0.	363.	0.	90.	74.
					0.	0.	0.
PERSNL PROV	430.	962.	7.	451.	0.	0.	0.
					-0.	-0.	-0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	25363.	1479.	0.	269.	0.	0.	0.
					0.	0.	0.
DRY WEIGHT	224142.	1479.	-0.	269.	1753.	11431.	11985.
					-11.	2.	167.
PERSONNEL	626.	951.	-1.	455.	0.	0.	0.
					-0.	-0.	-0.
LANDED CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
RESID FLUIDS	4001.	1385.	0.	279.	20.	252.	238.
					0.	-0.	-20.

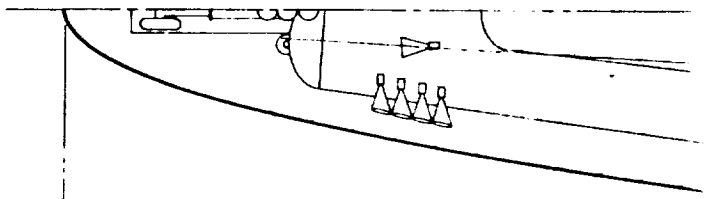
TABLE 4-4 (Cont.)

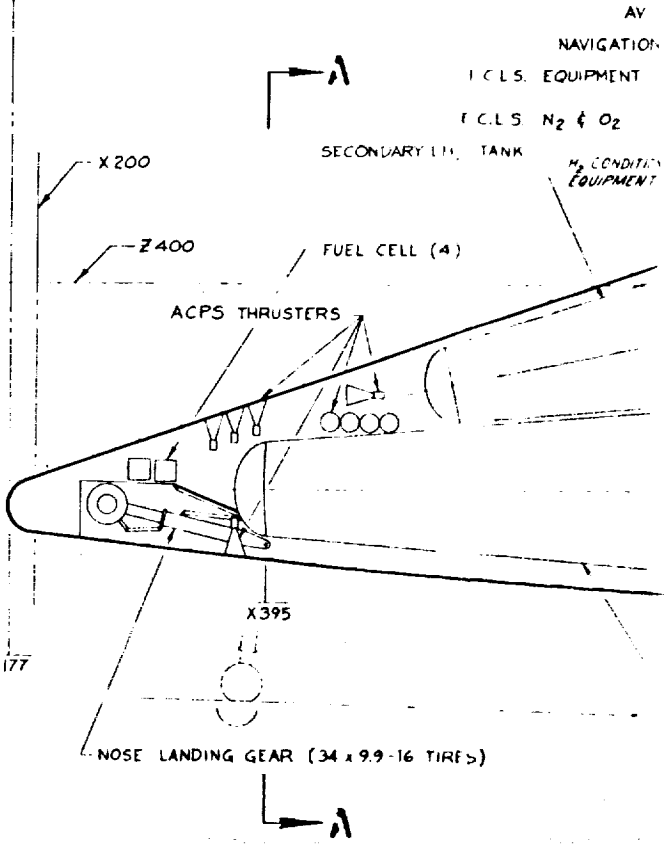
SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
65K EASTERLY MISSION
(DELTA ORBITER)

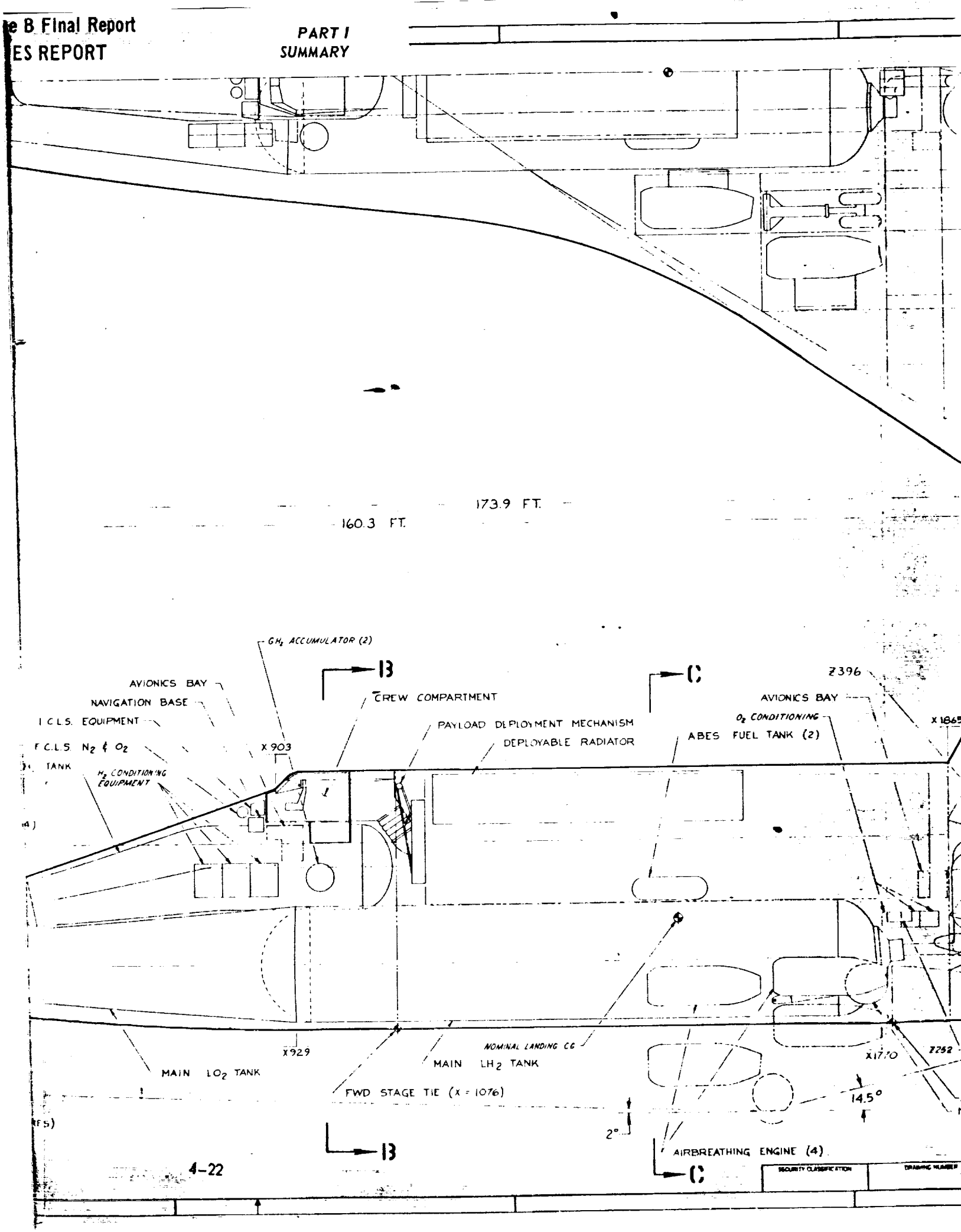
DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
INERT WEIGHT	268769.	1468.	-0.	289.	1038.	12201.	12703.
					-11.	2.	79.
RESERVE FLDS	6651.	1712.	0.	287.	12.	248.	255.
					0.	-0.	-23.
LANDING WT	275420.	1474.	-0.	289.	1050.	12622.	13041.
					-11.	2.	55.
CRUISE PROP	37.	17869.	0.	23401.	-4332.	-6389.	-2056.
					0.	0.	-3030.
FLIGHT WT	275457.	1476.	-0.	292.	1883.	12645.	13132.
					-11.	2.	42.
ENTRY ACS	1834.	1477.	-0.	307.	3.	105.	106.
					-0.	0.	-0.
ENTRY WT	277291.	1476.	-0.	293.	1885.	12751.	13238.
					-11.	2.	33.
RETRO PROP	5536.	1741.	0.	283.	0.	183.	180.
					0.	-0.	-16.
PRE RETRO WT	282827.	1481.	-0.	292.	1895.	13016.	13509.
					-11.	2.	14.
ON ORB LOSS	11360.	1600.	0.	295.	18.	568.	577.
					0.	-0.	-49.
LANDED CARGO	-40000.	1420.	0.	400.	-35.	-410.	-410.
					0.	0.	0.
ASCENT CARGO	65000.	1420.	0.	400.	57.	667.	667.
					0.	0.	0.
ON ORBIT WT	319187.	1481.	-0.	301.	1993.	13053.	14398.
					-11.	2.	-69.
MANEUV PROP	1993.	1741.	-0.	283.	3.	66.	68.
					-0.	0.	-6.
DUMPED PROP	10600.	813.	0.	228.	5.	84.	88.
					0.	-0.	-0.
INJECTION WT	331780.	1461.	-0.	298.	2012.	15137.	15577.
					-11.	2.	31.

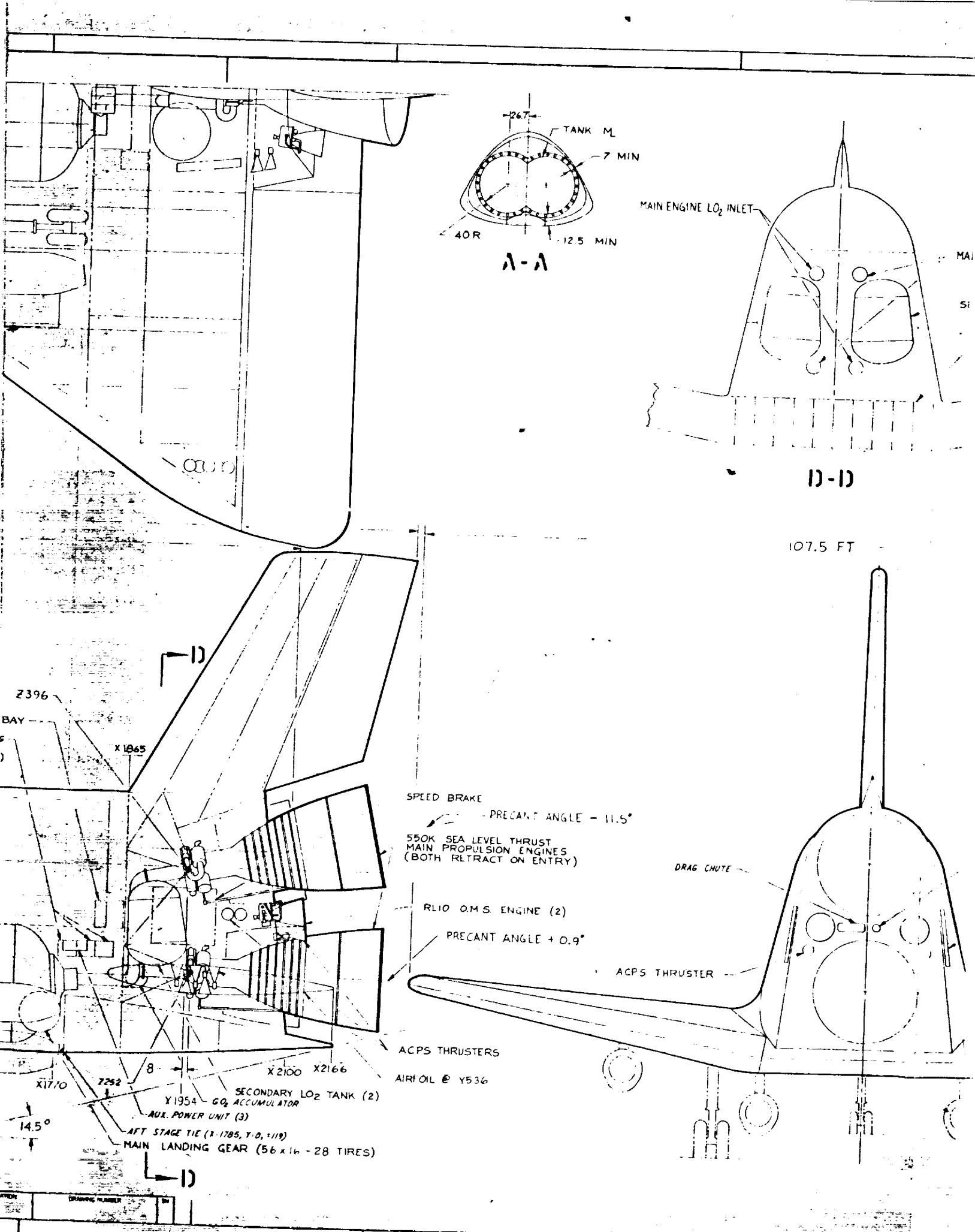
TABLE 4-4 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
65K EASTERLY MISSION
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ASCENT PROP	131860.	997.	0.	228.	103.	1946.	2048.
					0.	0.	-0.
75% BURN	463640.	1329.	-0.	278.	2216.	21574.	22015.
					-12.	2.	606.
ASCENT PROP	131701.	888.	0.	228.	89.	1421.	1500.
					0.	0.	1.
50% BURN	595341.	1231.	-0.	267.	2361.	27346.	27819.
					-13.	2.	1188.
ASCENT PROP	131569.	763.	0.	228.	64.	1034.	1098.
					0.	0.	0.
25% BURN	726910.	1147.	-0.	260.	2461.	33520.	34022.
					-14.	1.	1616.
ASCENT PROP	131570.	592.	-0.	228.	83.	892.	975.
					0.	0.	0.
IGNITION	858480.	1062.	-0.	255.	2563.	41824.	42383.
					-14.	1.	2045.
STARTUP	1062.	861.	0.	228.	1.	24.	25.
					0.	0.	0.
LAUNCH WT	860442.	1061.	-0.	255.	2570.	41865.	42425.
					-14.	1.	2047.

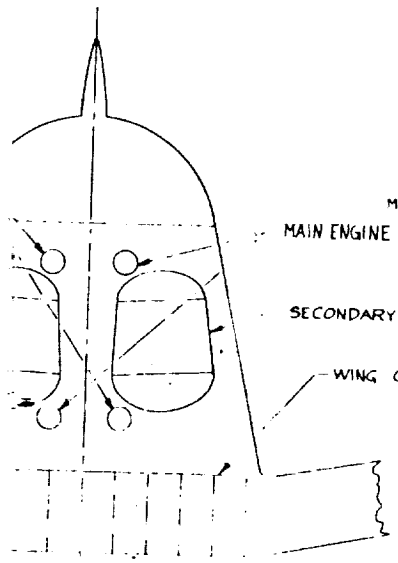



AV
NAVIGATION
E.C.L.S. EQUIPMENT
E.C.L.S. N_2 & O_2
SECONDARY L.H. TANK
H_2 CONDITIONING EQUIPMENT
X 200
Z 400
FUEL CELL (4)
ACPS THRUSTERS
X 395
X 177
NOSE LANDING GEAR (34 x 9.9-16 TIRES)

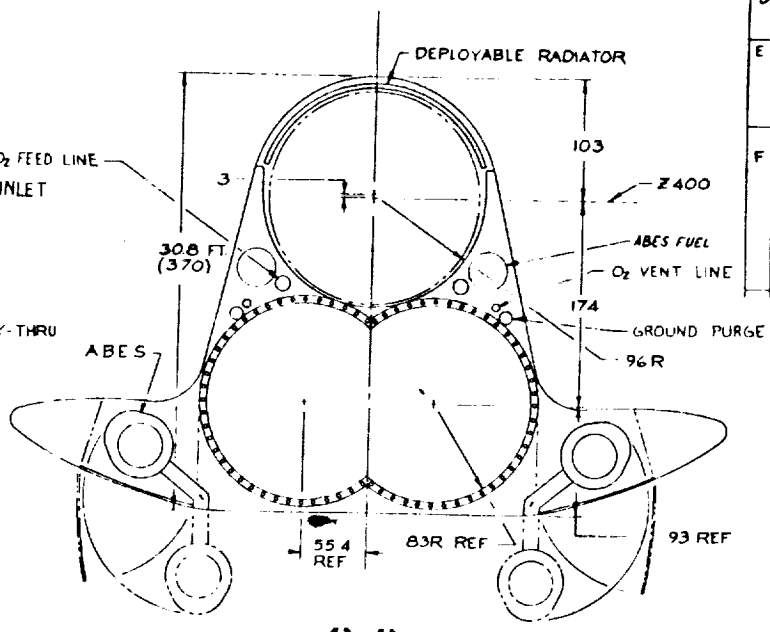

173.9 FT.
160.3 FT.
GH_2 ACCUMULATOR (2)
B
C
AVIONICS BAY
NAVIGATION BASE
I.C.L.S. EQUIPMENT
F.C.L.S. N_2 & O_2 TANK
H_2 CONDITIONING EQUIPMENT
X 903
CREW COMPARTMENT
PAYLOAD DEPLOYMENT MECHANISM
DEPLOYABLE RADIATOR
Z 396
AVIONICS BAY
O_2 CONDITIONING
ABES FUEL TANK (2)
X 1865
X 929
MAIN LO_2 TANK
NOMINAL LANDING CG
MAIN LH_2 TANK
X 1770
Z 252
FWD STAGE TIE (X = 1076)
14.5°
2°
B
AIRBREATHING ENGINE (4)
C


26.7
TANK ML
7 MIN
40 R
12.5 MIN
A-A
MAIN ENGINE LO2 INLET
D-D
107.5 FT
Z396
BAY
X1865
SPEED BRAKE
PRECANT ANGLE - 11.5°
550K SEA LEVEL THRUST
MAIN PROPULSION ENGINES
(BOTH RETRACT ON ENTRY)
DRAG CHUTE
RL10 O.M.S. ENGINE (2)
PRECANT ANGLE + 0.9°
ACPS THRUSTER
ACPS THRUSTERS
AIRFOIL @ Y536
X1770
Z252
8
X2100
X2166
Y1954
SECONDARY LO2 TANK (2)
GO2 ACCUMULATOR
AUX. POWER UNIT (3)
14.5°
AFT STAGE TIE (X-1785, Y-0, Z-119)
MAIN LANDING GEAR (56 x 16 - 28 TIRES)
D
D

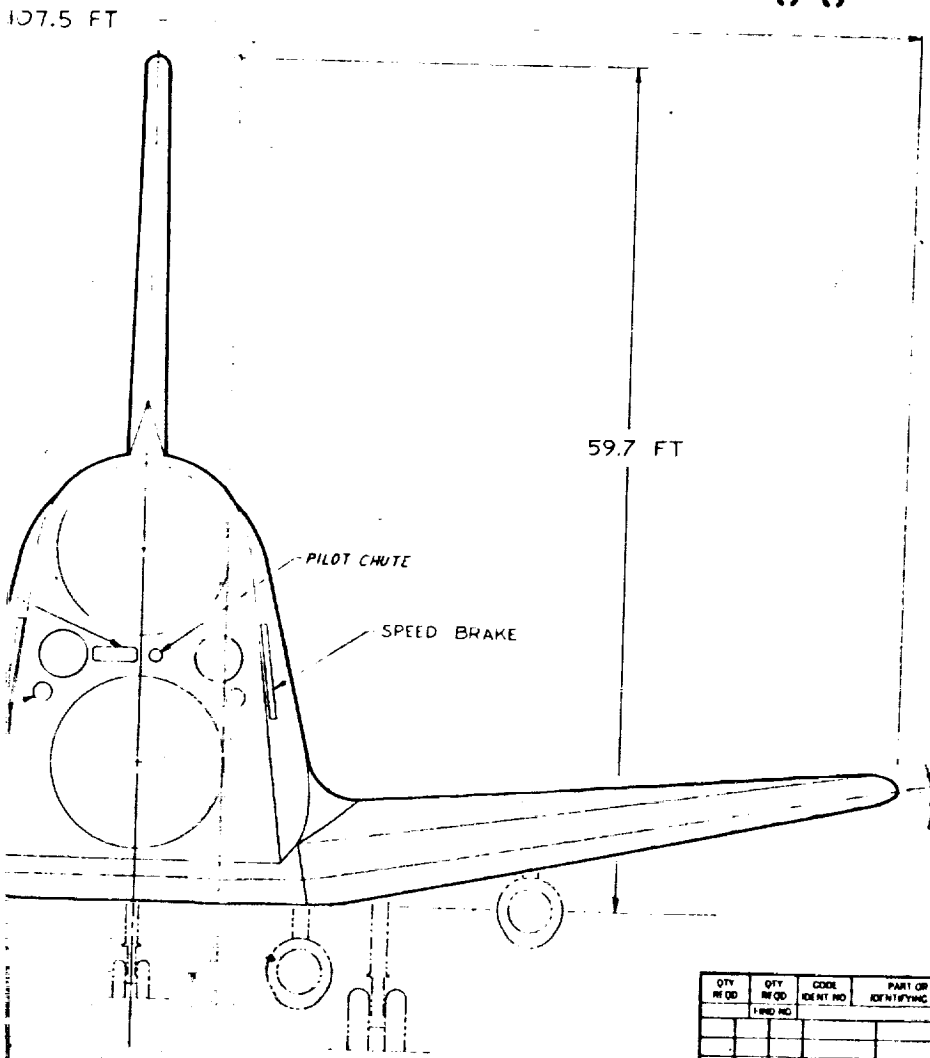
REVISIONS				
LTR	ZONE	DESCRIPTION	DATE	APPROVED
C		RESIZED PROPELLANT TANKS, ADDED 520K MAIN ENGINES, REVISED CREW COMPARTMENT	1/9/71	[illegible]
D		ADDED RL10 O.M.S. ENGINES, RESIZED ON-ORBIT TANKS, REVISED FWD AVIONICS BAY	1/15/71	[illegible]
E		REVISED CREW COMPARTMENT, PAYLOAD DEPLOYMENT MECHANISM & SECONDARY LH_2 TANK, ADDED 550K MAIN ENGINES	1/23/71	[illegible]
F		INCORPORATED 2.09 R. WING, REVISED ABES, RELOCATED AND RESIZED MAIN LANDING GEAR. RESIZED SECONDARY LH_2 TANK RELOCATED SECONDARY LO_2 TANK RELOCATED H_2 & O_2 CONDITIONING EQUIPMENT, RESIZED DEPLOYABLE RADIATOR, RELOCATED PILOT AND DRAG CHUTES	2/10/71	[illegible]

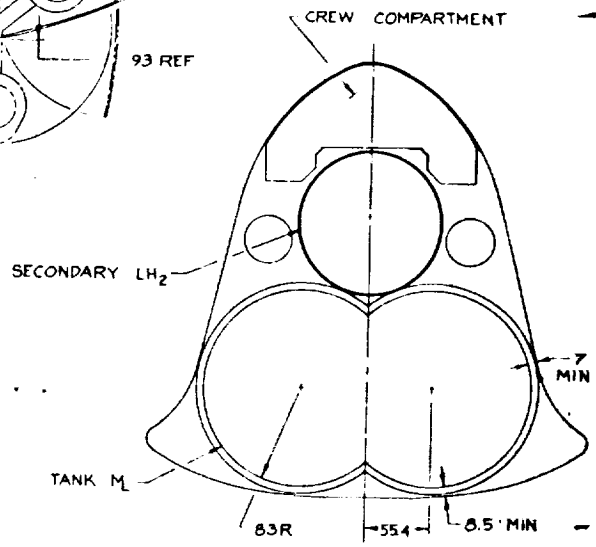


D-D

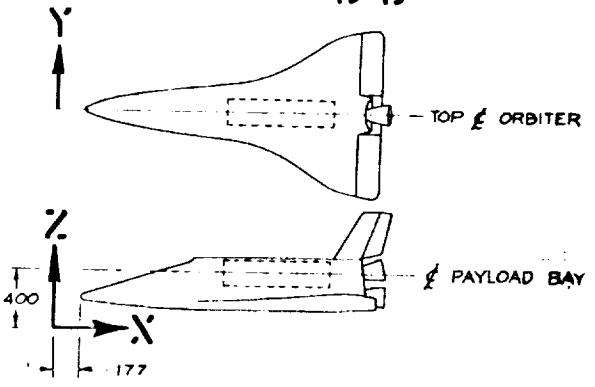


C-C





B-B



ALL DIM'S. IN INCHES EXCEPT AS NOTED.
NOTE. DIRECTION INDICATED IS POSITIVE.

ORBITER COORDINATE SYSTEM
REV. F 2/10/71
REV. E 1/23/71
REV. D 1/15/71
REDRAWN REV. C 1/9/71

QTY REQD	QTY REQD THRU NO.	CODE IDENT NO.	PART OR IDENTIFYING NO.	DRAWING OR SPECIFICATION NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL OR MATERIAL CODE	NOTE NO.	ZONE
					PARTS LIST				

LOFT DATA
LAYOUT NO.
TOLERANCE UNLESS NOTED
.X = ± .1
.XX = ± .03
.XXX = ± .010
FINISH SPEC
CONFIG NO.

DR T. SMITH 11/9/70
CHK [illegible] 9/2/70
STR
GP [illegible] 10/7/70 10/9/70
[illegible] 2/10/71

MCDONNELL
ST. LOUIS, MISSOURI

GENERAL ARRANGEMENT-
SIAMESE TANK,
DELTA WING ORBITER

SIZE J | CODE IDENT NO. | 255BJ00050 REV "F"
SCALE 1/50 | WT | SHEET 1 OF 2

DASH NO. | ASSY | NEXT ASSY | USED ON
QTY REQD | APPLICATION

5.0 Booster Summary - The Canard Booster data shown in this section and throughout the Detailed Mass Properties Report is based on the vehicle described by general arrangement drawing 256-20-0001 Revision A. A copy of this drawing is included as Figure 5-3 at the end of this section. Since there are no pending changes for the booster, the mass properties presented herein for the "analysis vehicle" are the same as those presented in Report E0403 for the "final design baseline".

In Table 5-1 Booster weight summaries are shown at key mission points from launch thru landing. Orbiter weight is not included in these summaries. Booster weight, center of gravity coordinates and moments of inertia at each mission point are shown graphically in Figure 5-1.

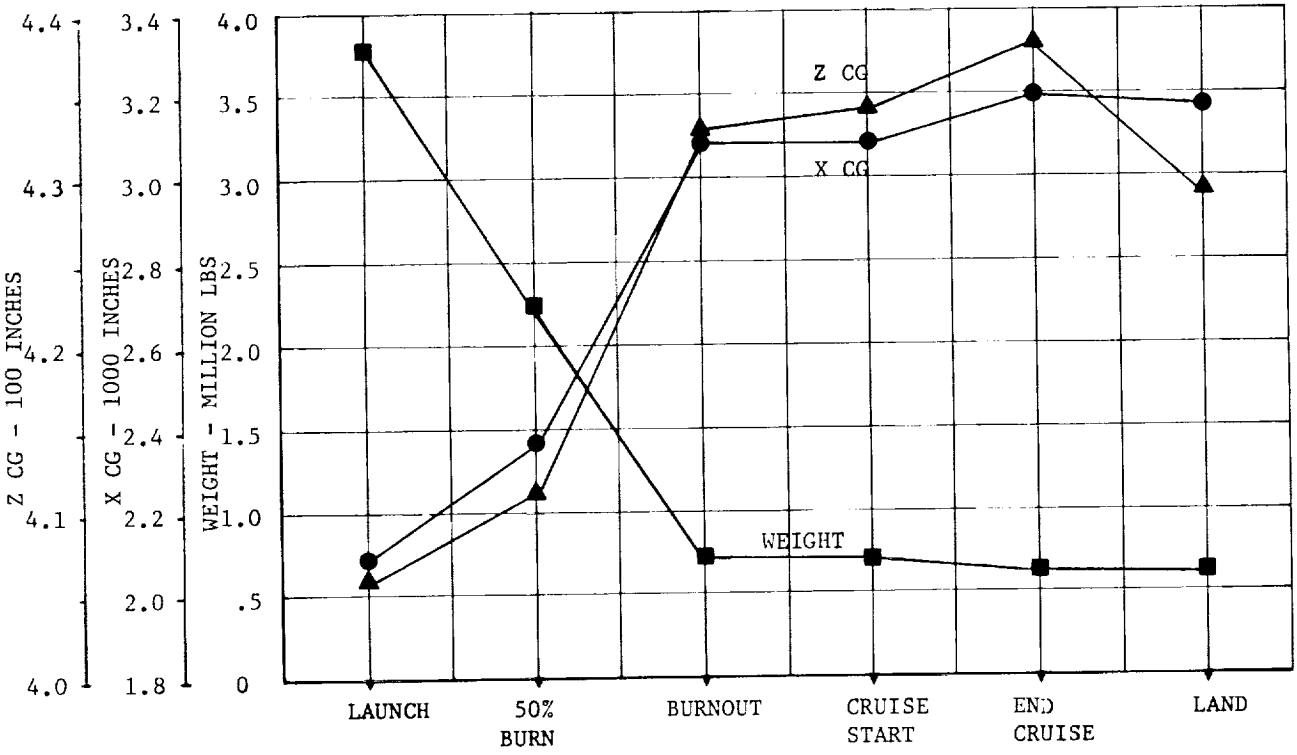
Tables 5-2 and 5-3 are the prescribed Space Shuttle Group Weight Statement and Design Data Summary. Figure 5-2 shows the Canard Booster configuration and describes the coordinate axes system used throughout this report for the Booster and combined vehicles.

Additional detail to support the sequenced mass properties shown in Figure 5-1, including summaries of items jettisoned between mission points, is presented in Table 5-4.

Figure 5-3 is the general arrangement drawing for the Canard Booster.

The data shown in this section is for the Easterly mission. The only Booster difference between missions is in the cruise fuel loading plus associated effects on reserve and residual fluids and on the available growth/uncertainty allowance. These differences are described in Appendix B.

FIGURE 5-1 WEIGHT, C.G.'s AND MOMENTS OF INERTIA VS MISSION POINT (CANARD BOOSTER)



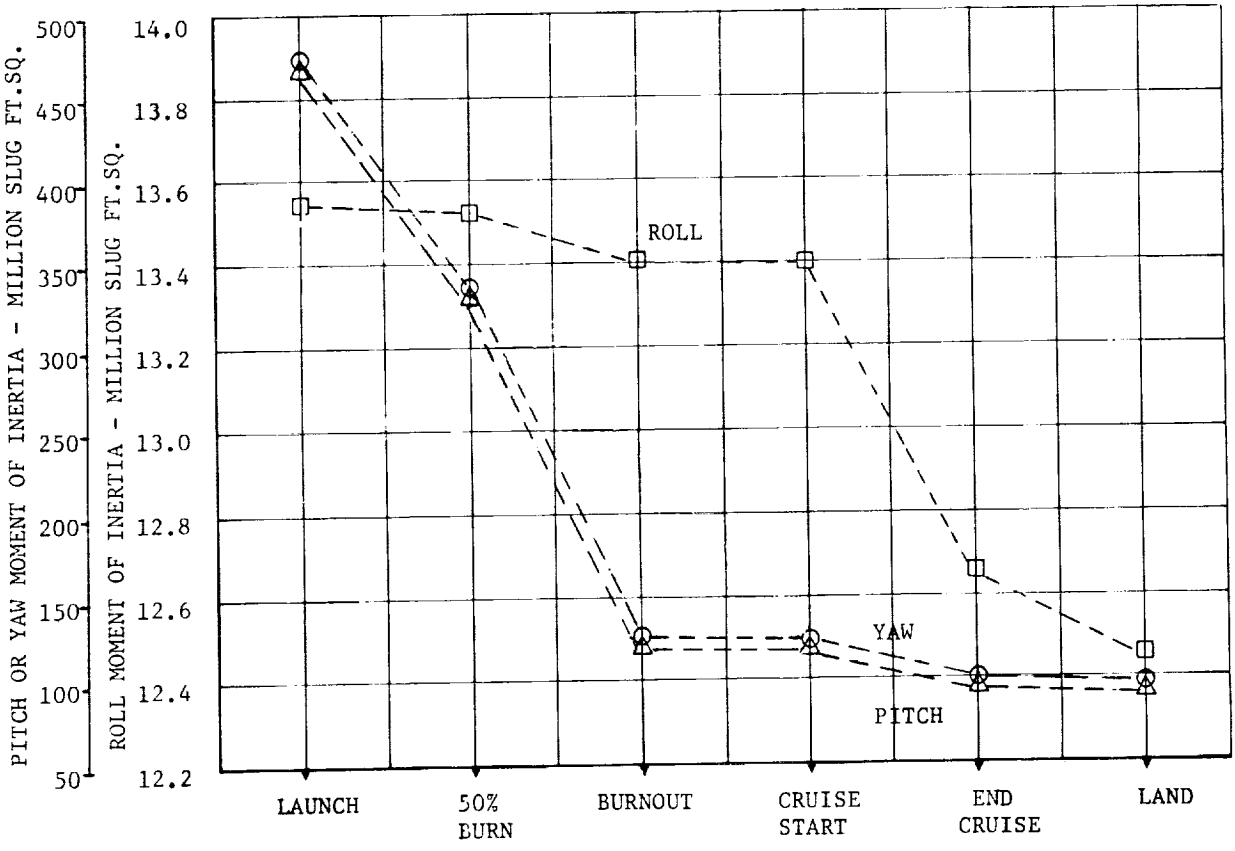


TABLE 5-1 MISSION WEIGHT SUMMARY

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	57954							
2	TAIL GROUP	19214							
3	BODY GROUP	148599							
4	INDUCED ENVIR PROTECTION	84807							
5	LANDING, RECOVERY, DOCKING	25885							
6	PROPULSION-ASCENT	123320							
7	PROPULSION-CRUISE	37053							
8	PROPULSION-AUXILIARY	5396							
9	PRIME POWER	3582							
10	ELECT CONVER & DISTR	1818							
11	HYDRA CONVER & DISTR	7282							
12	SURFACE CONTROLS	11320							
13	AVIONICS	4941							
14	ENVIRONMENTAL CONTROL	2058							
15	PERSONNEL PROVISIONS	288							
16	RANGE SAFETY & ABORT								
17	BALLAST								
18	GROWTH UNCERTAINTY	42009							
19									
	SUBTOTAL (DRY WEIGHT)	(575526)							
20	PERSONNEL	522							
21	CARGO								
22	ORDNANCE								
23	RESIDUAL FLUIDS	14707							
24									
	SUBTOTAL (INERT WEIGHT)	(590755)							
25	RESERVE FLUIDS	34245	34245	34245	34245	34245	245		
26	IN FLIGHT LOSSES	22847	22847	22847	2035				
27	PROPELLANT-ASCENT	3038600	1519300						
28	PROPELLANT-CRUISE	97000	97000	97000	97000	10000	10000		
29	PROPELLANT-MANEUV ACS	1212	1212	1212					
30									
	TOTAL (GROSS-WEIGHT) LB.	3784659	2265359	746059	724035	635000	601000		

DESIGNATORS:

EVENTS
A LAUNCH WEIGHT
B 50% BURN
C BURNOUT
D START CRUISE
E END CRUISE
F LANDING
G
H

NOTES & SKETCHES:

TABLE 5-2 GROUP WEIGHT STATEMENT — PAGE 1 OF 6

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 JUNE 1971

1. WING GROUP			CARRY THROUGH	EXPOSED SURFACE		57954
BASIC STRUCTURE			(15414)	(36220)	51634	
TORQUE BOX			15414	26820		
LEADING EDGE				9400		
TRAILING EDGE						
SECONDARY STRUCTURE						
VARIABLE GEOMETRY (INCL ____ LBS MECHANISM)						
DOORS, INSULATION, FAIRINGS						
CONTROL SURFACES			SURFACE	SUPT/MECH	6320	
AILERONS – (INCL. BAL WT_____LB)			5430	890		
T.E. FLAPS						
L.E. FLAPS						
SPOILERS						
SPEED BRAKES						
	VENTRAL VERTICAL	DORSAL VERTICAL	CANARD			
2. TAIL GROUP						19214
BASIC STRUCTURE	(5730)	(3214)	(6174)		15118	
TORQUE BOX	3310	2252	3944			
CARRY THROUGH						
LEADING EDGE	1154	962	1850			
TRAILING EDGE	1266		380			
SECONDARY STRUCTURE						
CONTROL SURFACES			SURFACE	SUPT/MECH	4096	
RUDDER (INCL. BAL WT_____LB)			2064	426		
ELEVONS			1149	457		
3. BODY GROUP						148599
INTEGRAL TANKAGE					102261	
FUEL TANK				61662		
OXIDIZER TANK				19769		
BETWEEN TANKS(INTERTANK)				16717		
INSULATION				4113		
BASIC STRUCTURE	FWD.	CTR,	AFT,	SKIRT		
	(967)	(_____)	(_____)	(37797)	38764	
SIDEWALLS (NOSE SHELL)	967					
BULKHEADS						
PARTITIONS						
THRUST STRUCTURE (MAIN ASCENT ENGINE)				37797		
SECONDARY STRUCTURE					7574	
CREW COMPARTMENT				1920		
EQUIPMENT COMPARTMENTS						
RADOME 'ANTENNAS						
SPEED BRAKES						
ENGINE HEAT PROTECTION						
INTERSTAGE (INCL. MECH._____LBS)						
DOORS/ (LANDING GEAR)				1302		
GEAR/WING PROVISIONS				4352		

TABLE 5-2 GROUP WEIGHT STATEMENT				PAGE 2 OF 6
CONFIGURATION	CANARD BOOSTER	BY		DATE 15 JUNE 1971

	WING	HOR. TAIL	VER. TAIL	BODY	
4. INDUCED ENVIRONMENT PROTECTION					(84807)
THERMAL PROTECTION					
LEADING EDGE/NOSE CAP*	(**)	(**)	(**)	( )	
SURFACE PROTECTION*	(16450)	(4524)	(6596)	(47969)	75539
STRUCTURE	7333	1920	2944	21201	
HCF	5203	1489	2035	14449	
COATING	2459	701	1009	7626	
~~BOND~~	~~1455~~	~~414~~	~~608~~	~~4693~~	
BASE HEAT PROTECTION*				( )	5678
STANDOFFS					3327
INSTRUMENTATION					263
SOUND PROTECTION					( )
METEORITE/RADIATION PROTECTION					( )

84807

*BREAK OUT BY TYPE OF MATERIAL
** METALLIC HOT - CHARGED TO WING AND TAIL GROUP STRUCTURE

TABLE 5-2	GROUP WEIGHT STATEMENT				PAGE 3 OF 6	
CONFIGURATION	CANARD BOOSTER	BY			DATE	15 JUNE 1971

5. LANDING, DOCKING			STRUC-	CON-		25885
ALIGHTING GEAR		ROLLING	TURE	TROLS	22590	
MAIN		5760	8250	1050		
NOSE		2880	4160	490		
DOCKING					0	
AUXILIARY SYSTEMS					3295	
DECELERATION CHUTES				0		
FLOTATION GEAR				0		
ORBITER ATTACH				3295		
CONTINGENCY					0	
6. PROPULSION – MAIN ASCENT						123320
ENGINE & ACCESSORIES					98241	
ENGINE (AS SUPPLIED)				89940		
GIMBAL SYSTEM				5516		
CHILLDOWN SYSTEM				632		
PNEUMATIC SYSTEM				2129		
HYDRAULIC ENGINE CONTROL				24		
INSTALLATION, DUCTS, SHROUDS					0	
PROPELLANT SY			FUEL	OXIDIZER	24579	
FILL DRAIN			801	690		
PRESSURIZATION			1559	1732		
VENT SY						
PCV SY			0	0		
PROPELLANT LOADING			40	35		
FEED SYSTEMS			6031	13691		
CONTINGENCY					500	
TANKAGE – NONINTEGRAL	TANK	INSULATE	SUPTS		0	
FUEL						
OXIDIZER						
7. PROPULSION – CRUISE BACK						37053
ENGINE & ACCESSORIES					28084	
ENGINE				26140		
LEVEL SENSING				130		
LUBRICATION SY (DRY)						
ACCESSORIES				1814		
INSTALLATION, DUCTS, SHROUD					3893	
AIR INDUCTION				1108		
ENGINE MOUNTING				195		
FIREWALLS				990		
EXHAUST SY				1600		
PROPELLANT SY					1428	
FILL/DRAIN & DUMP				139		
PRESSURIZATION (DRY & VENT)				246		
BLEED AIR SUPPLY				46		
PNEUMATIC ACTUATION				111		
FEED SY & TRANSFER				886		
TRANSFER SY						
DUMP SY						
SUPPORTS/INSTALLATION						
TANKAGE – NON INTEGRAL	TANK	INSULATE	SUPTS		2656	
FUEL					992	
CONTINGENCY						

TABLE 5-2 GROUP WEIGHT STATEMENT — PAGE 4 OF 6

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 JUNE 1971

8. PROPULSION – AUXILIARY					ATT. CONTROL		MANEU-VER	5396
THRUSTER INSTALLATION					549			
THRUSTER								
ACCESSORY								
PROPELLANT SY					1998			
FILL/DRAIN				110				
PRESSURIZATION				148				
VENT				216				
FEED SYSTEM				1524				
DUMP SYSTEM								
SUPPORTS								
TANKAGE					1802			
TANKS				510				
INSULATION				1292				
SUPPORTS								
CONTINGENCY					1047			
9. PRIME POWER	AIR BREATHERS	POWER UNIT	MTG INSTAL	PROPEL TANK/SYS	TEMP CONTROL	CON-TROLS	TOTAL	3582
BATTERIES		35					(35)	
ENGINE TURBINE	1816	486*	326	295	173	451	(3547)	
FUEL CELL							( )	
* INCLUDING ALTERNATORS								
10. ELECTRICAL			SUPPLY	CONVER-SION	CONTROL UNITS			1818
EQUIPMENT							676	
DISTRIBUTION AND CONTROL CIRCUITRY				192	484			
UTILITY SYSTEMS							853	
SUPPORTS/INSTALLATION							126	
							163	
11. HYDRAULIC			PRIMARY	UTILITY	EMERG			7282
			(7282)	(0)	(0)	7282		
POWER SUPPLY			900					
DISTRIBUTION CONTROL CTR			5879					
TEMPERATURE CONTROL SY			0					
AUXILIARY SYSTEMS			132					
SUPPORTS INSTALLATION			371					
12. SURFACE CONTROLS								11320
COCKPIT CONTROLS								
FLIGHT CONTROL SY			POWER		FEEL	SUPTS	(SEE AVIONICS)	
SYSTEM ACTUATION	CONTROLS		XMISSION	ACTUATOR	SY	INSTALL.		
	(153)		(690)	(8804)	( )	(1673)	11320	
ELEVON	69		451	6804		1293		
CANARD FLAP	23		32	440		84		
RUDDER	61		207	1560		296		
T.E FLAP								
SPEED BRAKE								
13. AVIONICS	UNITS		CIRCUITRY	COOLING	ANTENNAS	INSTALL.		4941
	(2770)		(698)	(N/A)	(88)	(759)		
GUID NAV	140		24	N/A	N/A	114	278	
FLIGHT CONTROL	865		175	N/A	N/A	119	1159	
DATA MANAGEMENT	835		242	N/A	N/A	140	1217	
COMMUNICATE	317		95	N/A	88	353	853	
CONFIG. SEQ,			SEE DATA MANAGEMENT					
INSTRUMENTATION			SEE DATA MANAGEMENT					
DISPLAYS	613		162	N/A	N/A	33	808	
CONTINGENCY							626	

TABLE 5-2 GROUP WEIGHT STATEMENT — PAGE 5 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 JUNE 1971

14. ENVIRONMENTAL CONTROL		2058
GAS SUPPLY SYSTEM (DRY)	120	
AIR CYCLE & PRESSURE CONTROL SYSTEM	308	
HEAT TRANSPORT SYSTEM (DRY)	455	
CABIN INSULATION	172	
PURGE SYSTEM	816	
CONTINGENCY	187	
15. PERSONNEL PROVISIONS		288
SEATS 'RESTRAINT SYS (NO =)	120	
FIXED LIFE SUPPORT EQUIPMENT	*	
EMERGENCY EQUIPMENT	29	
CARGO HANDLING	0	
FURNISHINGS	139	
* WEIGHT CHARGED TO ECLS		
16. RANGE SAFETY AND ABORT		0
17. BALLAST		0
18. GROWTH/UNCERTAINTY		42009
19. OPEN		0
SUBTOTAL (DRY WEIGHT)		(575526)

20. PERSONNEL	NO	MAN	GARMENTS	HELMET	PRESS. SUIT	ACCESSORIES		522
CREW	(2)	392	13	12	26	79	522	
PASSENGER	(0)						0	
PERSONEL GEAR 'ACCESSORIES							0	
LIFE SUPPORT							0	
FOOD								
EQUIPMENT – PORTABLE								
								0
21. CARGO								0
22. ORDNANCE								
23. RESIDUAL & UNUSABLE FLUIDS								14707
ASCENT							4796	
CRUISE							4045	
MANEUVER							0	
ATTITUDE CONTROL							306	
ECS							84	
APU							55	
HYDRAULIC							5381	
MISCELLANEOUS							40	
24. OPEN								0
SUBTOTAL (INERT WEIGHT)								(590755)

TABLE 5-2 GROUP WEIGHT STATEMENT — PAGE 6 OF 6

CONFIGURATION	CANARD BOOSTER	BY		DATE	15 JUNE 1971

25. RESERVE FLUIDS				10245
ASCENT			0	
CRUISE			10000	
MANEUVER			0	
ATTITUDE CONTROL			54	
ECS			0	
APU			191	
HYDRAULIC			0	
26. INFLIGHT LOSSES & APU PROP				22847
ASCENT			20320	
CRUISE			0	
MANEUVER			0	
ATTITUDE CONTROL			9	
ECS			0	
APU			2035	
HYDRAULIC			0	
MISCELLANEOUS			483	
27. PROPELLANT – ASCENT				3038600
28. PROPELLANT – CRUISE				121000
NOMINAL USABLE – 87000				
DUMPED RESERVE – 34000				
		MANEUV.	ACS	
29. PROPELLANT – MANEUV ACS		0	1212	1212
TOTAL (GROSS WEIGHT)				3784659

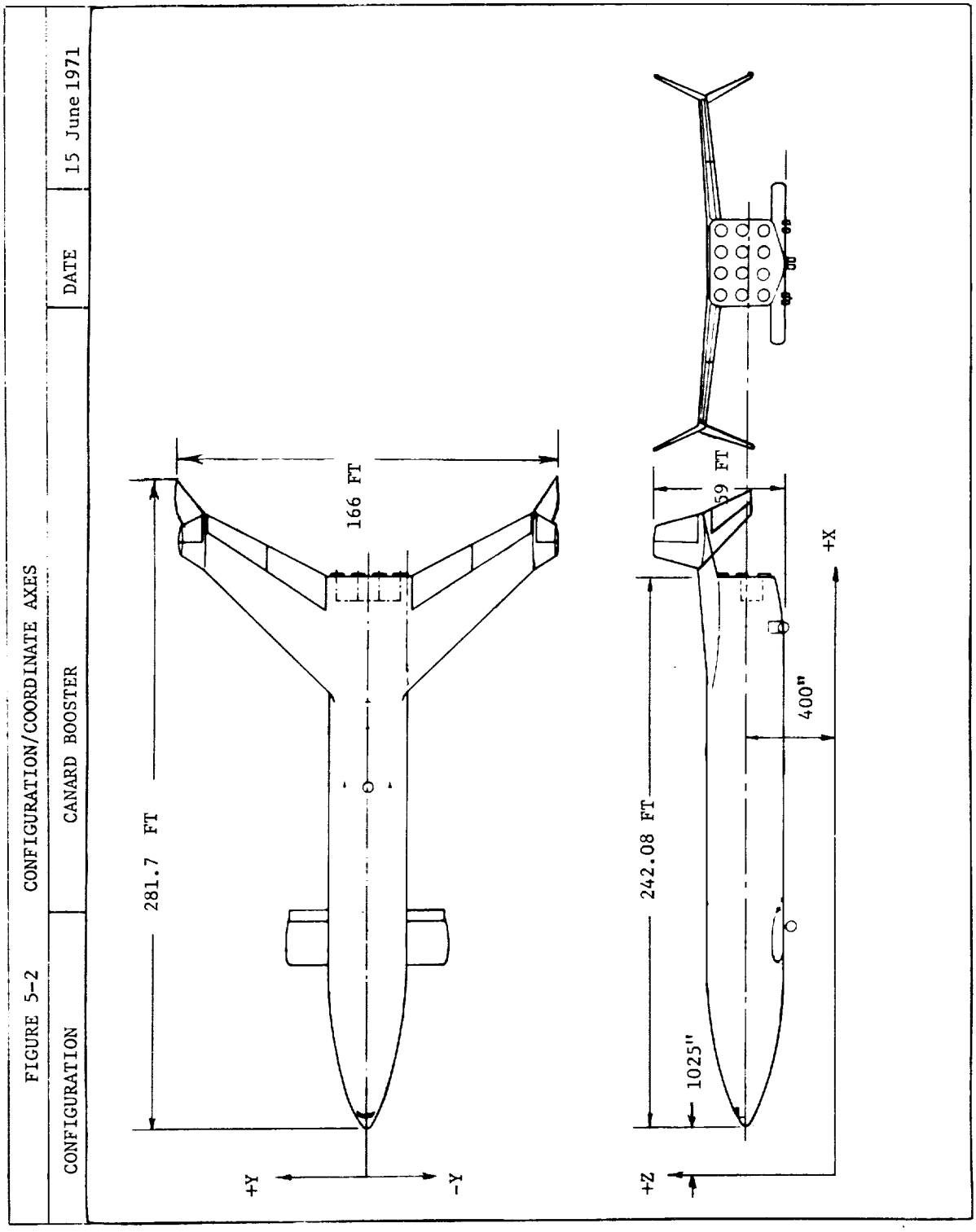


FIGURE 5-2 CONFIGURATION/COORDINATE AXES
CONFIGURATION
CANARD BOOSTER
DATE
15 June 1971
166 FT
281.7 FT
+Y
-Y
59 FT
242.08 FT
400"
1025"
+X
+Z

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 1 OF 8

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 JUNE 1971

MAX DYNAMIC PRESSURE, LB./SQ. FT. +958 (LOAD COND. 4)*
MAX $q\alpha$ PSF DEGREE 5686 (LOAD COND. 4)*
ENTRY VELOCITY FT./SEC 10824 (EASTERLY MISSION)
BALLISTIC COEFFICIENT W/C_dA, LB./SQ. FT. 89.4
ENTRY ANGLE DEGREES $\frac{}{50}$

ULTIMATE LOAD FACTOR	Nx	Ny	Nz	WEIGHT, LB **
ASCENT	4.30(COND.10)	-0.30(COND.6)	-0.52(COND.8)	N/A
ABORT				
SEPARATION				
ENTRY	-0.33(COND.11)	0.0(COND. 11)	-5.98(COND.11)	722642
CRUISE	-0.59(COND.12)	0.0(COND.12)	-3.49(COND.12)	722642
LANDING	-1.72(COND.18)	0.29(DRIFT)	-3.51(COND.17)	588235

1. WING GROUP

	INSIDE FUSELAGE	EXPOSED	
GROSS AREA SQ FT	(1947.6)	(4068.0***)	6015.6***
TORQUE BOX	626.7	1271.6	
LEADING EDGE (FIXED)	N/A	1497.5	
TRAILING EDGE (FIXED)	N/A	332.0	
MOVABLE SURFACES	N/A	966.9	
VOLUME – CU. FT		12032	

	MAC	ROOT THEORETICAL	BODY JUNCTION STA.235	PLANFORM BREAK	TIP
CHORD LENGTH (FT)	43.33	57.50	48.53	N/A	25.00
CHORD THICKNESS FT)		6.15	5.19	N/A	2.68

SPAN BETWEEN CHORDS (FT)
DIHEDRAL ANGLE (DEG) 7.67 SPAN BETWEEN DIHEDRAL BASES FT 39.17
SWEEP BACK ANGLE (MEAN CHORD) 37° 25% CHORD 40°
AIRFOIL DESCRIPTION NACA 0010.7-64
TAPER RATIO .435
THICKNESS CHORD: ROOT 0.107 TIP 0.107
DESIGN LOAD SEE BOOSTER TECHNICAL SUMMARY (E0308-II-3) SECTION 3.1.7.2 (DES. LOADS)
CRITICAL LOAD CONDITION SEE BOOSTER TECH. SUMMARY

CONTROL SURFACES	TYPE	AREA – SQ FT RETRACT	EXTEND
T.E. FLAPS	N/A	N/A	N/A
L. E. FLAPS	N/A	N/A	N/A
SPOILERS			
SPEED BRAKES			

PRIMARY STRUCTURAL MATERIALS	MATERIAL	DESIGN TEMP °F
TORQUE BOX	7075-T73	200
LEADING EDGE		
TRAILING EDGE (FIXED)		
MOVABLE SURFACES		

NOTES:
* SEE BOOSTER TECHNICAL SUMMARY (E0308-II-3) SECTION 3.1.7.2 (DESIGN LOADS) FOR DESCRIPTION OF LOADING CONDITIONS AND COMPLETE DESIGN LOAD SUMMARY
** ESTIMATED LOADS USED FOR LOADS ANALYSIS - NOTE THESE VALUES MAY DIFFER FROM FINAL WEIGHTS.
*** THEORETICAL AREA.

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 2 OF 8

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 JUNE 1971

2. TAIL GROUP	VENTRAL VERTICAL	DORSAL VERTICAL	CANARD ****		
EXPOSED AREA FT^2 (TOTAL)	(874.0)	(874.0)	(943.8)	( )	
TORQUE BOX	274.1	218.8	564.6		( )
LEADING EDGE (FIXED)	180.6	180.6	242.0		( )
TRAILING EDGE (FIXED)	419.3	108.0	137.2		( )
MOVABLE SURFACES	N/A	366.6	202.0		( )
CARRY THROUGH AREA – FT^2	N/A	N/A	311.1		
EXPOSED SEMI-SPAN – FT	23.0	23.0	24.2**		
CARRY THROUGH SPAN – FT	N/A	N/A	26.67		
NO. OF SURFACES VEHICLE	2	2	1		
VOLUME – CU FT	1071	1071	6040		
PRIMARY STRUCT.MATERIAL	7075-T73	7075-T73	7075-T73		
CHORD LENGTH					
ROOT (THEORETICAL) FT.	25.0	25.0	19.5*		
MAC FT.	19.67	19.67	19.5*		
BODY, JUNCTION	N/A	N/A	19.5*		
TIP, FT.	13.0	13.0	19.5*		
CHORD MAX. THICKNESS					
ROOT, FT	2.21	2.21	5.93		
TIP, FT	1.18	1.18	5.93		
DIHEDRAL ANGLE, DEGREE	N/A	N/A	N/A		
SWEEPBACK, 25% CHORD	48°	6°	0		
CRITICAL LOAD CONDITION	SEE BOOSTER TECH. SUMMARY (E0308-II-3) SECTION 3.1.7.2 (DESIGN LOADS)				

3. BODY GROUP	FWD BULKHEAD	BARREL	AFT BULKHEAD	COMMON BULKHEAD	
INTEGRAL TANK WETTED AREA – FT^2					22901
OXIDIZER TANK	236	4791	1145	N/A	(6172)
FUEL TANK	1145	12018	1145	N/A	(14308)
INTER-TANK STRUCTURE	N/A	2421	N/A	N/A	(2421)
ULLAGE PRESSURE – PSI	OXIDIZER ____		FUEL ____		
BASIC STRUCTURE WETTED AREA – FT^2	FWD	CTR	AFT	SKIRT	
	( )	( )	( )	(3930)	
SIDEWALLS	SAME AS ABOVE				
BULKHEADS					
PARTITIONS					
THRUST STRUCTURE (MAIN ASCENT ENGINE)				3930***	
BODY VOLUME – CU FT (TOTAL					(228985)
PRIMARY STRUCTURAL MATERIAL	2219-T87	2219-T87	2219-T87	7075-T73	

* REFERENCE CHORD
** TO CANARD TIP
*** WING/BODY INTERCEPT @ STA. 235
**** MOVEABLE SURFACE (JET FLAP) NOT INCLUDED

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 3 OF 8

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 June 1971

3. BODY GROUP (CONTINUED)

MISCELLANEOUS	WETTED AREA-SQ.FT.	VOLUME CU. FT.	ULT DES. PRESS. DIFF. – PSI
CREW COMPARTMENT	295	400	24.4
EQUIPMENT COMPARTMENT			
RADOME ANTENNAS			
SPEED BRAKES	N/A		
DOORS FAIRINGS			
TANKS – OXIDIZER			
TANKS – FUEL			

4. INDUCED ENVIRONMENT PROTECTION

	WING	CANARD	VER.TAIL	BODY	
TOTAL VEH. WETTED AREA-FT^2	8391	2397	3598	26121	(40507)
LEADING EDGE NOSE CAP AREA – SQ FT	(310)	(96)	(223)	(50)	679
MATERIAL	COLUMBIUM	HASTELLOY	COLUMBIUM & HASTELLOY	HASTELLOY	
MATERIAL					
MATERIAL					
SURFACE PROT. AREA- SQ. FT.	(8081)	(2301)	(3375)	(26071)	39828
MATERIAL	HCF	HCF	HCF	HCF	
MATERIAL					
MATERIAL					
MATERIAL					
MATERIAL					
MATERIAL					
MATERIAL					
MATERIAL					
UNPROTECTED AREA-SQ FT	(_____)	(_____)	(_____)	(_____)	NONE
BASE MATERIAL: HCF				(_____)	1309*
TOTAL VEHICLE VOLUME – CU. FT. (OUTER MOLDLINE)	12032	5520	2240	211783	(231575)
VOLUME INSIDE PRIMARY STRUCTURE – CU FT	10651	5136	1633	207604	(225024)
TPS VOLUME CU FT	1381	384	607	4179	(6551)
LEAD. EDGE NOSE CAP RAD-FT.	0.4725**	0.6375	0.165**	2.00	
LEAD. EDGE NOSE CAP MAX TEMP °F	2400	1810	2440	1945	
LOWER SURFACE MAX TEMP °F	2300	1775	1550(OB)	1975	
SIDE SURFACE MAX TEMP°F	N/A	N/A	N/A	1000/2880***	
UPPER SURFACE MAX TEMP°F	775	800	2100(IB)	925/2040****	

NOTES:

* BASE AREA PLUS INERNAL BOATTAIL (PROJECTED BASE AREA = 1076 SQ FT)
** AVERAGE ROOT/TIP
*** SIDE FUSELAGE BELOW WING
**** BOOSTER/ORBITER INTERFERENCE REGION
OB OUTBOARD SURFACE
IB INBOARD SURFACE

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 4 OF 8

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 JUNE 1971

5. LANDING, RECOVERY, DOCKING

ALIGHTING GEAR	NO. VEH	DESIGN LOAD – LB	EXTENDED *** STRUT LGTH– FT	STROKE FT	PRIMARY MATL	BRAKE MATL
MAIN GEAR	2	*	9.45	2.50	STL	CARBON
NOSE GEAR	1	*	8.17	3.42	STL	CARBON

MAX. DESIGN LANDING WT – LB. = 601000 (EASTERLY MISSION)
LANDING SPEED – KNOTS = 180
ANGLE OF ATTACK @ LANDING – DEG = 6

LIMIT LANDING SINK SPEED
____ FT SEC @ ____ LB. LANDING WEIGHT
10 FT SEC @ 601000 LB. MAX DESIGN LANDING WEIGHT

SEPARATION SYSTEM
DESIGN "q" @ SEPARATION – PSF = 23.17 (EASTERLY MISSION)
MAX. AXIAL ACCELERATION – g's = 3.00
MAX. DESIGN SEPARATION – WT LB. = 746059 (EASTERLY MISSION)

DECELERATION CHUTE
DIAMETER – FT – N/A
NO. VEHICLE – N/A

6. PROPULSION – MAIN ASCENT

	THRUST–SL	THRUST–VAC	EXP RATIO	I_{sp} VAC	CHAMB PRES PSI
ENGINE	550,000	604,000	35	439**	3000

PROPELLANT SYSTEM	FUEL	OXIDIZER	(OPERATING LIMIT)
ULLAGE PRES. – PSI			(4125)
PROPEL TYPE	LH_2	LO_2	
ULLAGE VOL – FT^3	3008	1117	
PRESSURANT	GH_2	GO_2	
TOTAL TANK VOL – FT^3	107803	38667	(146470)
USABLE PROP VOL – FT^3	100274	37224	(137498)
TOTAL LEN OF FEEDLINES – FT	17	169	

TANKAGE – NONINTEGRAL	NO.	SHAPE	WET AREA SQ FT	VOLUME CU FT
OXIDIZER	N/A	N/A	N/A	N/A
OXIDIZER				
OXIDIZER				
FUEL				
FUEL				
FUEL				

NOTES:
* SEE BOOSTER TECHNICAL SUMMARY (E0308-II-3) SECTION 3.1.7.2 (DESIGN LOADS)
** NOMINAL VALUE, 3 MIN IS 436 SEC
*** VERTICAL HEIGHT AXLE TO TRUNNION

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 5 OF 8

CONFIGURATION: CANARD BOOSTER — BY: — DATE:

7. PROPULSION – CRUISEBACK

NO. OF ENGINES	10
ENGINE THRUST – S.L. STATIC – LB	CLASSIFIED
SPECIFIC FUEL CONSUMPTION LB LB – THRUST PER HR	CLASSIFIED
NOMINAL CRUISE ALTITUDE – FT	18000
NOMINAL CRUISE SPEED – KNOTS	328
CRUISE ALTITUDE ENGINE OUT – FT	14000
CRUISE SPEED, ENGINE OUT – KNOTS	330
CRUISE RANGE (ACTUAL REQ) – NA MI	450
CRUISE RANGE (MAX AVAIL – NO HEADWIND, ALL ENGINES UP)	640
CRUISE LIFT DRAG RATIO	6.75 (ENGINE OUT W/HEADWINDS)
NO. ENGINES SIZED BY	10K INITIAL ALT & ENG. OUT LANDING ABORT
LIFT COEFFICIENT FOR CRITICAL THRUST CONDITION	.28 @ 10K INITIAL ALT .54 @ ENG OUT LANDING ABORT

	TYPE	TANK VOL CU FT	TANK MATL	TANK PRES-PSI	BURST FACTOR	NO. OF TANKS
FUEL SYSTEM	JP-4	4825	ALUM	3-5 PSIG	2.0	4
PRESSURIZATION SYSTEM	AIR					

AIR INTAKE – LENGTH-FT.
– DIAMETER-FT
NACELLE WETTED AREA – EACH-SQ FT: INTEGRAL WITH CANARD

8. PROPULSION – AUXILIARY

THRUSTERS

THRUST (VAC) – LB	I_{SP} – SEC	ACS	QUANTITY REQ MANEUVER	COMBIN	
1600	379 STEADY	16	0	0	(16)
	360 PULSE				( )
					( )
					( )
					( )

PROPELLANT SYS	TYPE	TANK VOLUME	TANK MATL	TANK PRES.PSI	BURST FACTOR	NO. OF TANKS
FUEL	LH_2	135	2219-T87	34	2.0	1
OXIDIZER	LO_2	20	2219-T87	34	2.0	1
FUEL PRESSURANT	GH_2	*				
OXIDIZER PRESS.	GO_2	*				

9. PRIME POWER

	SPECIFIC POWER		TOTAL POWER		TYPE
BATTERIES	10	WATT-HR LB	360	WATT-HRS	NI-CAD
ENGINE TURBINE (TOTAL)	0.826	HP-HR LB FUEL	1600	HP-HR	H_2-O_2/JP4-AIR
H_2-O_2 = 6.0/JP4-AIR =	2.0	HP-LB OF ENGINE		HP	
FUEL CELL	N/A	WATT-HRS LB FUEL	N/A	WATT-HRS	N/A
	N/A	WATTS LB OF FUEL CELL	N/A	WATTS	

* AUTOGENOUS SYSTEM

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 6 OF 8

CONFIGURATION: CANARD BOOSTER | BY: | DATE:

10. ELECTRICAL POWER CONVERSION/DISTRIBUTION

SYSTEM VOLTAGE = 120 VOLTS - DC
PEAK POWER = 41500 WATTS
AVERAGE POWER = 21000 WATTS

11. HYDRAULIC POWER CONVERSION DISTRIBUTION

SYSTEM NOMINAL OPER PRESSURE = 3000 PSI
PEAK POWER = 1460 HORSEPOWER
AVERAGE POWER (APPROX) = 150 HORSEPOWER
TOTAL VOLUME OF FLUID = 100 FT^3
FLUID TYPE MIL-M-5606 MAX OPER TEMP - °F 275

12. SURFACE CONTROLS

SURFACE	AREA FT^2	MAX DEFL RATE DEG/SEC	MAX DEFL DEG	DESIGN HINGE MOM. FT/LB	NO/ VEHICLE
RUDDER/SURF	187	30	+30	200,000	2
IB ELEVON/SURF	268	30	+30,-40	500,000	2
OB ELEVON/SURF	249	30	+30,-40	500,000	2
JET FLAP/SIDE	103	10	+45,-12.5	41,000	2

13. AVIONICS

14. ENVIRONMENTAL CONTROL

	TOT. STOR VOL-FT^3	STORAGE PRES.	TANK MATL	NO. OF TANKS
GAS SUPPLY SYSTEM	(1.918)			(3)
PRIMARY AIR	0.9	3000	CARBON FILAMENT	2
EMERGENCY OXYGEN	0.118	3000	"	1
DILUENT				

GAS REQUIREMENT AVERAGE RATES
METABOLIC = 2.0 LB MAN-DAY
LEAKAGE = 30 LB /HR
REPRESSURIZE = -- LB REPRESSURIZE
PRESSURIZED SURFACE AREA - FT^3
HEAT TRANSPORT SYSTEM CAPACITY = N/A BTU HR (PEAK)
= 46000 BTU HR (AVE)
RADIATOR AREA - N/A SQ FT N/A MATERIAL

WATER MANAGEMENT SYSTEM CAPACITY

DRINKING WATER = N/A LB MAN-DAY x _____ MAN DAYS
WASHING = N/A LB MAN-DAY x _____ MAN DAYS
COOLING = N/A LB BTU x _____ BTU's

15. PERSONNEL PROVISIONS

16. RANGE SAFETY AND ABORT

TABLE 5-3 DESIGN DATA SUMMARY				PAGE 7 OF 8	
CONFIGURATION	CANARD BOOSTER	BY		DATE	15 June 1971

17. BALLAST
DESIGN C.G. ENVELOPE FWD - SUBSONIC 72.3 HYPERSONIC 68.9 %L AFT - 77.7 74.2 %L
NOMINAL C.G. WITHOUT BALLAST - 75.3 %L (SUBSONIC) & 70.5%L (HYPERSONIC)
NOMINAL C.G. WITH N/A LB BALLAST - N/A %L
MAX DESIGN LANDING WT-LB 601000 @ -63.4 % MAC. C.G.

18. GROWTH UNCERTAINTY

CURRENT ALLOWANCE - 42009 LB (EASTERLY MISSION)
CONTRACTORS EST OF ALLOWANCE NEEDED TO GUARANTEE
CURRENT PAYLOAD AND GROSS WT _____ LB*
REMAINING GROWTH ALLOWANCE FOR
CUSTOMER CHANGES - _____ LB

* FOR SYSTEM REQUIREMENTS AS DEFINED BY _____

19. OPEN

20. PERSONNEL
NO. OF CREW - 2 ; AVE PERCENTILE MAN - 90
NO. OF PERSONNEL 0 ; AVE PERCENTILE MAN - N/A
TOTAL

21. CARGO CARGO BAY VOLUME - N/A CU FT
BAY DIA - N/A FT
BAY LGTH N/A FT

22. ORDNANCE

23. RESIDUAL FLUIDS – DEFINE WEIGHT ESTIMATING RATIONALE

24. OPEN

25. RESERVE FLUIDS

26. INFLIGHT LOSSES

TABLE 5-3 DESIGN DATA SUMMARY — PAGE 8 OF 8

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 JUNE 1971

(EASTERLY MISSION)

27 – 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO (BY WEIGHT)	6	N/A	N/A	
OXIDIZER ULLAGE VOLUME – PERCENT*	3.0		N/A	5.0
FUEL ULLAGE VOLUME – PERCENT*	3.0	**	N/A	5.0
FUEL DENSITY – PCF	4.395	49.0	N/A	4.395/49.0
OXIDIZER DENSITY – PCF	71.0	N/A	N/A	71.0/N/A
FUEL BIAS – % USABLE PROP.	.156			
INCREMENTAL VELOCITY – FPS	(14991)		N/A	
INERTIAL	10824			
ANGLE OF ATTACK	37			
GRAVITY LOSSES	3345			
DRAG LOSSES	516			
BACK PRESSURE LOSSES	269			
FLT. PERFORMANCE RESERVE				
RANGE – NA MI		(640)		
GROUND MILES		454		
HEAD WIND /ENGINE OUT ALLOW.		186		
CONTINGENCY				
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING GO-AROUND–MINUTES		5.1		

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES.

** N/A – TANKS ARE OVER SIZED TO FACILITATE C.G. MANAGEMENT

TABLE 5-4 SEQUENCED MASS PROPERTIES SUMMARY 06/10/71
CANARD BOOSTER EASTERLY MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	57954.	3707.	0.	509.	2638.	244.	2809.
					0.	0.	16.
TAIL&CANARD	19214.	3278.	0.	475.	2466.	4689.	6714.
					0.	0.	889.
BODY	148599.	2816.	0.	395.	985.	20749.	20719.
					0.	0.	-109.
THERMAL PROT	84807.	3053.	0.	441.	3071.	14592.	16806.
					0.	0.	1124.
LANDING GEAR	25885.	3098.	0.	286.	153.	3035.	2960.
					0.	0.	-28.
ASCENT PROP	123320.	3708.	0.	430.	274.	4706.	4767.
					5.	0.	-235.
CRUISE PROP	37053.	2111.	0.	249.	235.	1196.	1302.
					1.	0.	203.
ORIENT SYS	5306.	2331.	14.	546.	8.	447.	453.
					-5.	0.	-1.
SURF CONTROL	11320.	3851.	0.	618.	883.	465.	1271.
					0.	0.	109.
PRIME POWER	3582.	3654.	0.	281.	1.	22.	22.
					0.	0.	0.
ELEC CON/DIS	1818.	2209.	0.	507.	2.	35.	34.
					0.	0.	4.
HYDRAULICS	7282.	3700.	0.	400.	4.	16.	16.
					0.	0.	0.
AVIONICS	4941.	1838.	0.	429.	5.	938.	937.
					0.	0.	9.
LAUNCH ESC	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
ECLS	2058.	2352.	0.	435.	6.	482.	477.
					0.	0.	14.
PERS PROV	288.	1120.	0.	423.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
PEND CHNGS	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH	42000.	3095.	0.	420.	91.	3264.	3264.
					0.	0.	0.
DRY WT	575526.	3164.	0.	426.	11725.	87174.	93850.
					-14.	2.	5388.
PERSONNEL	522.	1110.	0.	425.	0.	0.	0.
					0.	0.	0.
RESIDUALS	14707.	2837.	2.	421.	129.	2970.	3030.
					-4.	1.	49.

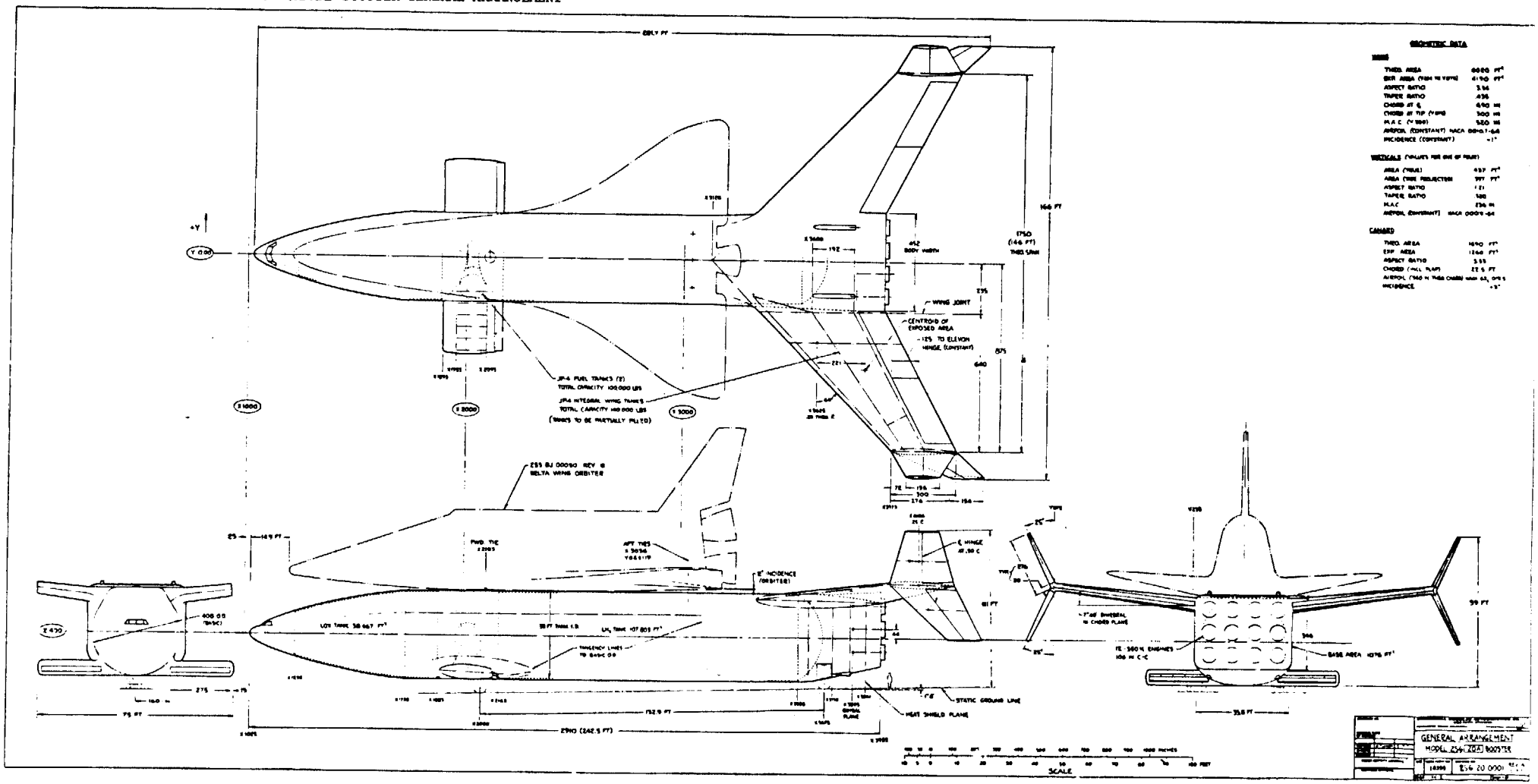
TABLE 5-4 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/10/71
CANARD BOOSTER EASTERLY MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
RESERVE	10245.	3801.	0.	599.	540.	172.	711.
					-1.	-0.	6.
LANDING WT	601000.	3165.	0.	429.	12459.	92094.	99304.
					-21.	3.	5690.
CRU RESR DMP	34000.	3845.	0.	600.	0.	0.	0.
					0.	0.	0.
END OF CRUSE	635000.	3201.	0.	438.	12663.	95512.	102519.
					-22.	3.	6499.
CRU PRO USED	87000.	2257.	0.	400.	715.	7096.	7588.
					0.	0.	882.
APU PROP	2035.	2023.	6.	540.	0.	-0.	0.
					0.	0.	0.
CRUISE START	724035.	3084.	0.	434.	13407.	117844.	125314.
					-22.	3.	7931.
INFLT LOSS	20812.	3313.	1.	402.	1.	2214.	2213.
					-4.	0.	-11.
ORIENT PROP	1212.	2023.	82.	400.	0.	0.	0.
					0.	0.	0.
PEND CHNGS	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BURN OUT WT	746059.	3089.	0.	433.	13415.	120589.	128055.
					-48.	3.	7898.
ASCENT PROP	759650.	2111.	0.	400.	0.	49800.	49800.
					0.	0.	0.
75% BURN	1505709.	2596.	0.	416.	13503.	248154.	255534.
					-23.	4.	10501.
ASCENT PROP	759650.	1938.	0.	400.	0.	36507.	36507.
					0.	0.	0.
50% BURN	2265359.	2375.	0.	411.	13531.	331865.	339216.
					-11.	4.	11666.
ASCENT PROP	759650.	1764.	0.	400.	0.	23195.	23195.
					0.	0.	0.

TABLE 5-4 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/10/71
CANARD BOOSTER EASTERLY MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
25% BURN	3025009.	2222.	0.	408.	13546.	400878.	408214.
					-3.	4.	12475.
ASCENT PROP	759650.	1605.	0.	400.	-0.	17496.	17496.
					0.	0.	0.
LAUNCH WT	3784659.	2098.	0.	406.	13554.	468285.	475613.
					3.	4.	13129.

FIGURE 5-3 CANARD BOOSTER GENERAL ARRANGEMENT



DETAILED WEIGHT STATEMENT

(DELTA ORBITER)

DETAIL WEIGHT STATEMENT

Item	Weight	Page No.
Wing Group	31587	
Basic Structure		
Torque Box	[14788]	2.1-15-52
Covering	(6338)	
Skin	3998	
Stringers	2340	
Spars	(2428)	
L.E. Spar	408	2.1-54-56
Aux. Front Spar	158	2.1-57-59
Aux. Rear Spar	512	2.1-57-59
Front Spar	672	2.1-60-73
Mid Spar	404	2.1-60-73
Rear Spar	274	2.1-60-73
Ribs	(6072)	
Root Rib	1952	2.1-74-84
Rib 2	594	2.1-85-88
Rib 2A	100	
Rib 2B	150	
Rib 3	1408	2.1-89-92
Rib 3A	100	2.1-99-100
Rib 4	284	2.1-93-95
Rib 4A	218	2.1-93-95&99-100
Rib 5	426	2.1-96-98
Rib 5A	308	2.1-96-98
Rib 5B	136	2.1-93-95&99-100
Rib 5C	100	2.1-99-100
Rib 5D	70	2.1-99-100
Rib 6	60	2.1-99-100
Inb'd ACS	76	
Outb'd ACS	40	2.1-99-100
Carry Thru	[2735]	
Covering	(1726)	2.1-103-104
Skin	950	
Stringers	776	
Ribs	(1009)	
BL 0 Rib	123	2.1-105
BL 28 Rib	210	2.1-106
BL 55 Rib	236	2.1-107
BL 85 Rib	212	2.1-108
BL 119 Rib	228	2.1-109
Leading Edge	[5272]	2.4-5
Carbon-Carbon L.E.	(1636)	
Columbium L.E.	(510)	
Columbium Strake	(3126)	

Item	Weight	Page No.
Secondary Structure		
Doors	[2286]	2.1-110
MLG Door Provisions	(518)	
Fwd ABES Door Provision	(884)	
Aft ABES Door Provision	(884)	
Control Surfaces		
Elevon	[3634]	2.1-115
Covering	(2066)	2.1-116-117
Skin	1496	
Stringers	570	
Front Spar	(220)	2.1-118-119
Ribs	(742)	2.1-120&121
Intercostals	(52)	2.1-120
Flipper Doors	(370)	2.1-119
Hinges	(184)	
Contingency	[2872]	2.1-4

Detail Weight Statement

(Tail Group)

Item	Weight	Page No.
Tail Group	5104	
Basic Structure		
Torque Box	[2649]	2.2-11
Covering	(1238)	2.2-14
Skin	743	
Stringers	495	
Front Spar	(266)	2.2-14
Caps	203	
Web	63	
Mid Spar	(300)	2.2-15
Caps	220	
Web	80	
Rear Spar	(229)	2.2-15
Caps	172	
Web	57	
Ribs	(1411)	2.2-16-19
Hinge Ribs (2)	54	
Drive Ribs (2)	60	
Intermediate (15)	337	
Cap Rib (1)	18	
Leading Edge	[731]	2.4-5
Carbon-Carbon	(422)	
Attachment	(107)	
Insulation	(202)	
Control Surfaces		
Rudder	[1260]	2.2-20
Covering	(885)	2.2-22
Skin	522	
Stringers	351	
Close-out	12	
Front Spar	(87)	2.2-22
Caps	35	
Web	52	
Ribs	(192)	
Intermediate (13)	109	2.2-22-24
Drive (2)	42	
Hinge (2)	16	
Cap (2)	25	
Hinge Fittings	(96)	2.2-20
Contingency	[464]	2.2-3

DETAIL WEIGHT STATEMENT
BODY GROUP

Item	Weight	Page No.
Body Group	55500	
Integral Tankage	[20648]	
Fuel Tank	(9734)	
Sidewall	8864	2.3-21-25
Baffles	282	2.3-38
Aft Bkhd	588	2.3-35
Oxidizer Tank	(6042)	
Sidewall	5670	2.3-26-32
Baffles	224	2.3-38
Fwd Bkhd	144	2.3-36
Common Bulkhead	(2876)	2.3-37
Insulation	(1996	2.3-39
Basic Structure	[21824]	
Fwd Section	(5292)	
Sidewall	1928	2.3-45-50
Bulkhead	2664	2.3-51-59
Longerons	700	2.3-40-44
Center Section	(9548)	
Sidewall	2566	2.3-45-50
Bulkheads	5928	2.3-51-74
Longerons	1054	2.3-40-44
Skirt Section	(6984)	
Sidewall	2105	2.3-96 &102-104
Frames	3609	2.3-75-85&97-101
Thrust Post	1270	2.3-105-114
Secondary Structure	[7982]	
Doors	(3318)	2.3-122-131
Payload Door	1819	
Payload Door Mech.	1051	
LH_2 OMS Tank Access	448	
Crew Compartment	(1799)	2.3-115-120
Crew Cab	548	
Airlock	625	
Windshield	385	
Hatches	241	
Equipment Compartment	(631)	2.3-121
Fwd Cpt	507	
Aft Cpt	124	
Speed Brake	(534)	2.3-132
Structural Prov.	(330)	
Nose Gear Prov.	330	2.3-136
Interstage	(1370)	2.3-133-135
Contingency	[5046]	2.3-4

		Weight-lbs	Page
Induced Environment Protection		32847	2.4-5
Thermal Protection		[29861]	
Leading Edge/Nose Cap		(350)	
Wing L.E & Strake	5272*		
Body Flap L.E.	N/A		
Vertical Tail L.E.	731*		
Body-Nose Cap	350		
Surface Protection		(27625)	
Wing		8330	
Columbium	2211		
Hastelloy X	3713		
Insulation & Bagging	2406		
Horizontal Tail/Body Flap		752	
Hastelloy	518		
Insulation & Bagging	234		
Body		18543	
Columbium	4545		
Hastelloy X	3809		
Rene 41	1244		
Inconel 718	1007		
Titanium	1046		
Insulation & Bagging	6892		
Base Heat Protection		(1886)	
Base Heat Protection	1100		
Main Engine Heat Protection	786		
Contingency		[2986]	

* Wing and Tail Leading Edge weights are shown here for reference only. They are included in the wing and tail group respectively.

	Weight-lbs	Page
Landing, Recovery, Docking	10951	
Alighting Gear	(7600)	2.5-2
Main Right Hand	3312	
Main Left Hand	3312	
Nose	976	
Docking	(400)	2.5-11
Auxiliary System	(1763)	2.5-18
Deceleration Chutes	258	2.5-18
Interstage Attach	627	2.5-23
Payload Handling	505	2.5-30
Tunnel	373	2.5-35
Contingency	(788)	2.5-36
Alighting Gear	380	
Docking	40	
Deceleration Chutes	13	
Interstage Attach	176	
Payload Handling	142	
Tunnel	37	

Propulsion - Main Ascent	26637 Lb	
		Page No.
Engine & Accessories	[19422]	
Engine	17620	2.6-2
Gimbal System	709	2.6-3
Ignition and Control System	833	2.6-4
Propellant Utilization System	260	2.6-5
Propellant System	[6206]	
Fuel	(2574)	
Fill/Drain	170	2.6-6
Pressurization/Vent	1242	2.6-8
Recirculation	93	2.6-10
Pre-Valves	334	2.6-12
Feed System	512	2.6-12
Vortex, Flow Control Sys	223	2.6-13
Oxidizer	(3632)	
Fill/Drain	120	2.6-6
Pressurization/Vent	616	2.6-7
Recirculation	90	2.6-10
Pre-Valves	528	2.6-11
Feed System	2059	2.6-11
Vortex Flow Control System	219	2.6-13
Contingency	[1009]	2.6-2

Propulsion – Cruise Back	574	
		Page No.
Engine & Accessories	(11282)*	2.7-3
Engine	10660	
Ignition and Control	30	
Lubrication System (Dry)	95	
Accessories	497	
Installation, Ducts, Shroud	(2962)*	2.7-4
Air Induction	62	
Engine Mounting	439	
Nacelles/Pylons	1567	
Deployment Provisions	894	
Propellant System	(338)	2.7-7
Fill/Drain	57	2.7-6
Pressurization (Dry)	13	2.7-6
Vent System	10	2.7-6
Feed System	163	2.7-7
Transfer System	47	2.7-6
Supports/Installation	48	2.7-7
Tankage	(175)	2.7-8
Tanks	79	
Insulation	44	
Supports	52	
Contingency	(516)	2.7-2
Increment for Resupply	455*	
Easterly and Polar	61	

*Not included in Easterly or Polar Missions.

Propulsion - Auxiliary	11877	Page No.
Attitude Control	[9957]	
Thruster Installation	(1291)	2.8-3
Thruster	1038	
Accessory	253	
Propellant System	(3664)	
Fill/Drain	423	2.8-4
Pressurization	444	2.8-5
Vent	150	2.8-6
Feed System	892	2.8-7
Accumulators	1062	2.8-9
Conditioning Equipment	693	2.8-9
Tankage	(3935)	2.8-10
Tanks	1749	
Insulation	1648	
Supports	538	
Contingency	(1067)	2.8-2
Maneuver	[1920]	
Thruster Installation	(667)	2.8-3
Thruster	607	
Accessory	60	
Propellant System	(1112)	
Feed System	1112	2.8-8
Contingency	(141)	2.8-2

		Page No.
Prime Power	2272	
Engine/Turbine	[925]	2.9-8
Turbine Power Unit	(368)	2.9-8
Temp. Control System	(264)	2.9-8
Controls	(48)	2.9-8
Mtg/Installation	(245)	2.9-8
Turbine/H.X. Mounts	120	2.9-8
APU Vent Line	125	2.9-10
Fuel Cell	[1051]	2.9-9
Power Unit	(980)	2.9-9
Mounting Structure	(36)	2.9-9
Temp. Control	(24)	2.9-9
Controls	(11)	2.9-9
Contingency	[296]	2.9-3

Electrical	1303	
Equipment		
Supply	[90]	2.10-7
Control Units	[511]	2.10-8
Power Distribution Units	(226)	2.10-8
Main Power Control Units	(216)	2.10-8
AC Controllers	(69)	2.10-8
Distribution & Control Circuitry	[435]	2.10-9
Primary Feeders	(342)	2.10-10
Secondary Feeders	(93)	2.10-9
Utility Systems (Landing Lights)	[30]	2.10-8
Supports/Installation	[24]	2.10-8
Contingency	[213]	2.10-3

Hydraulic	2760	
		Page No.
Power Supply	[552]	2.11-10
Main Pump	(320)	2.11-10
Reservoir	(232)	2.11-13
Distribution Control Ctr.	[704]	2.11-10
Pump Manifold	(189)	2.11-10
Valves and Controls	(217)	2.11-10
Circuitry	(96)	2.11-10
Plumbing	(208)	2.11-18
Temperature Control System	[284]	2.11-10
Cryo H_2 H.X.	(240)	2.11-19
Valves and Controls	(12)	2.11-19
Plumbing & Misc.	(32)	2.11-19
Auxiliary Systems	[88]	2.11-10
Secondary Elec. Pump	(80)	
Circuitry	(8)	
Supports/Installation	[420]	2.11-10
Local Mounting	(82)	2.11-27
Equip. Bay Structure	(338)	2.11-27
Contingency	[712]	2.11-3

Surface Controls	4901	
		Page No.
Elevon Controls	[138]	2.12-7
Circuitry	(35)	2.12-12
Linkage	(103)	2.12-13
Elevon Power Xmission	[97]	2.12-7
Pressure Lines	(65)	2.11-18
Return Lines	(32)	2.11-18
Elevon Actuator	[2068]	2.12-7
Elevon Secondary Actuator	[52]	2.12-7
Elevon Supts Install	[227]	2.12-7
Actuator Supt	(220)	2.12-13
Secondary Act Mtg.	(7)	2.12-13
Rudder Controls	[57]	2.12-7
Circuitry	(18)	2.12-12
Linkage	(39)	2.12-13
Rudder Power Xmission	[48]	2.12-7
Pressure Lines	(34)	2.11-18
Return Lines	(14)	2.11-18
Rudder Actuator	[465]	2.12-7
Rudder Secondary Act.	[26]	2.12-7
Rudder Supts Install	[67]	2.12-7
Actuator Supt	(64)	2.12-13
Secondary Act. Mtg.	(3)	2.12-13
Speed Brake Controls	[72]	2.12-8
Circuitry	(8)	2.12-12
Linkage	(64)	2.12-13
Speed Brake Power Xmission	[8]	2.12-8
Pressure Lines	(5)	2.11-18
Return Lines	(3)	2.11-18
Speed Brake Actuator	[913]	2.12-8
Speed Brake Secondary Act.	[52]	2.12-8
Speed Brake Supts Install	[130]	2.12-8
Actuator Supt	(123)	2.12-13
Secondary Act. Mtg.	(7)	2.12-13
Contingency	[481]	2.12-5

		Page No.
Avionics	4588 lb	
Guidance and Navigation	[516]	2.13-8
Inertial Measurement Unit	(140)	
Star Tracker	(120)	
Horizon Sensor	(32)	
Circuitry	(62)	
Navigation Base	(80)	
Local Mounting Structure	(19)	
Equipment Bay Structure	(63)	
Flight Control System	[327]	2.13-11
Thruster Electronics	(68)	
Actuator Electronics	(114)	
Rate Gyro Package	(16)	
Total Temp & Press Sensor	(10)	
Accelerometer	(6)	
Static Press Sensor	(10)	
Circuitry	(44)	
Local Mounting Structure	(14)	
Equipment Bay Structure	(45)	
Data Management	[1202]	2.13-11
Central Computer	(340)	
System Control Unit	(7)	
Mass Memory	(32)	
Area DIU's	(139)	
Crew Station DIU's	(137)	
IMU DIU's	(20)	
Maintenance Recorder	(100)	
Input/Output Control Unit	(24)	
Data Bus	(27)	
Circuitry	(238)	
Local Mounting Structure	(32)	
Equipment Bay Structure	(106)	
Communications & Navaids	[929]	2.13-13
S-band Equipment	(102)	
Audio Control Center	(36)	
Remote Intercom	(7)	
UHF Transceiver	(24)	
UHF Antenna	(26)	
UHF Ant Window & Instl.	(30)	2.13-29
S-band Antenna	(9)	
DME Receiver	(90)	
DME Antenna	(4)	
DME Ant Window & Instl.	(50)	2.13-30
Glide Slope Receiver	(12)	
Glide Slope Antenna	(6)	
GS Ant Window & Instl.	(32)	2.13-30
VOR/Localizer Receiver	(60)	
VOR/LOC Antenna	(32)	

Avionics - Cont.

		Page No.
Communications & Navaids Cont.		
VOR/LOC Ant Window & Instl.	(66)	2.13-31
Radio Altimeter	(63)	
Radio Alt. Antenna	(6)	
Radio Alt. Ant. Window & Instl.	(71)	2.13-31
Circuitry	(117)	
Local Mounting Structure	(20)	
Equipment Bay Structure	(66)	
Displays and Controls	[1015]	
Center Front Panel	(107)	2.13-16
Command Pilot Panel	(131)	2.13-17
Pilot Panel	(128)	2.13-18
Command Pilot Obd Panel	(29)	2.13-20
Pilot Obd Panel	(21)	2.13-21
Center Console Panel	(145)	2.13-22
Floor Area	(90)	2.13-23
Overhead Panels	(30)	2.13-24
Docking Station	(13)	2.13-24
Window Frame Mount	(6)	2.13-24
Local Mounting Struct.	(29)	2.13-24
Cockpit Panels	(95)	2.13-24
Circuitry	(191)	2.13-24
Contingency	[599]	2.13-3

Environmental Control [7849]

	Weight Coded Elsewhere		Page No.
Atmospheric Gas Storage and Supply		[166]	
Oxygen-Primary	(60)	N/A	2.14-35
Oxygen-Secondary	(17)	N/A	2.14-35
Dilutant Gas (Nitrogen)	(81)	N/A	2.14-35
Tankage			
O_2 - Primary	OAMS	N/A	
O_2 - Secondary		(21)	2.14-13
Dilutant - N_2		(100)	2.14-12
O_2 Delivery Equipment		(10)	2.14-13
N_2 Delivery Equipment		(8)	2.14-12
Mounting and Supports - O_2		(8)	2.14-13
Mounting and Supports - N_2		(19)	2.14-12
Gas Management/Processing		[685]	
Cabin Gas Control System CO_2/Odor Removal		(99)	2.14-15
Lithium Hydroxide Cartridges		(70)	2.14-17
Cannisters		(51)	2.14-17
Activated Charcoal	In Cartridge	N/A	
Fans		(76)	2.14-17
Humidity Control			
Condensing H-X		(31)	2.14-17
Window Defog H-X		(53)	2.14-17
Water Separators	[1](13)	N/A	
Cabin Temperature Control			
H-X		(50)	2.14-17
Fans	[2](76)	N/A	
Controls		(10)	2.14-17
Cabin Ventilation			
Fans	[2](76)	N/A	
Ducting		(203)	2.14-17

[1] See heat transport.
[2] See CO_2/Odor Removal.

Environmental Control - Cont.

	Weight Coded Elsewhere		Page No.
Gas Management/Processing - Cont.			
Atmosphere Pressure & Composition Control			
Insulation	See Insulation	N/A	
Mounting & Supports, Etc.		(42)	2.14-17
Heat Transport Subsystem		[2009]	
Cabin Circuit Coldplates (Dry)		(41)	2.14-20
Cabin Circuit Plumbing (Dry)		(6)	2.14-20
Cabin Circuit Reservoir (Dry)		(5)	2.14-20
Cabin Circuit Pump Package (Dry)		(30)	2.14-20
Condensate Water Subsys. (Dry)		(13)	2.14-20
Cabin Circuit Fluid	(96)	N/A	2.14-42
Interface H-X		(93)	2.14-20
Equipment Circuit Coldplates(Dry)		(139)	2.14-24
Temp. Control Panels (Dry)		(98)	2.14-24
Equipment Circuit Plumbing (Dry)		(65)	2.14-25
Equipment Circuit Pump Package(Dry)		(59)	2.14-24
Equipment Circuit Reservoir(Dry)		(24)	2.14-24
Equipment Circuit Fluid	(435)	N/A	
Radiator (Dry)			
Panels		(757)	2.14-49
Controls/Mechanisms		(440)	2.14-49
Ground Cooling H-X		(9)	2.14-24
Hydrogen Boiler/H-X		(96)	2.14-25
Water Boiler/Sublimator		N/A	
Insulation	See Insulation	N/A	
Valves and Controls		(55)	2.14-20&24
Mounting and Supports, Etc.		(79)	2.14-21&25
Water Management		[345]	
Water	(40)	N/A	
Tankage (Accumulators)		(77)	2.14-27
Pressurant System		N/A	
Plumbing/Controls		(37)	2.14-27
Insulation	See Insulation	N/A	
Mounting and Supports, Etc.		(22)	2.14-27
Waste Management Sys.		(192)	2.14-29
Mounting and Supports, Etc.		(17)	2.14-29

Environmental Control - Cont.

	Weight Coded Elsewhere	Page No.
Purge System & Fire Extinguish	[1119]	
Purge Liner	(677)	2.14-32
Supply & Discharge Headers	(426)	2.14-32
Fire Extinguishers	(16)	2.14-29
Insulation	[2877]	2.14-33
Cabin/Airlock	(286)	
Pwr/Cool. Transfer Tunnel	(855)	
N.L.G. Bay	(53)	
M.L.G. Bays	(519)	
Actuators		
Elevons	(163)	
Rudder	(63)	
Speedbrakes	(10)	
Fwd Equip Bay	(270)	
Aft Equip Bay	(25)	
N.L.G. Equip Bay	(182)	
Hydraulics Bay	(36)	
Cruise Engines	(415)	
Contingency	[648]	2.14-7

			Page No.
Personnel Provisions		430 Lb	
Crew Seats (2 - Command Pilot & Pilot)		[159]	2.15-2
Seats		(153)	
Safety Belt		(4)	
Harness Reel		(2)	
Fixed Life Support Equipment		[130]	
Food & Utensil Stowage		(40)	2.15-8
Water Storage Tank		(20)	2.15-8
Galley Equipment		(70)	2.15-2
Oven	10		
Freezer	50		
Water Heater	5		
Water Cooler	5		
Emergency Equipment		[30]	2.15-9
Furnishings		[91]	
Privacy Curtains		(3)	2.15-9
Partitions - Non-structural		(12)	2.15-8
Equipment Stowage Provisions		(76)	2.15-8
Lockers	27		
Pressure Suit Stowage	17		
Equipment Cabinets	32		
Contingency (5%)		[20]	
Growth/Uncertainty		25363 Lb	2.18-2

		Page No.
Personnel	626 Lb	
Crew	[433]	
Crew Members (2)	(392)	2.20-2
Constant Wear Garmets (2)	(2)	2.20-2
Headsets (2)	(1)	2.20-2
Helmets (2)	(12)	2.20-2
Pressure Suits (2)	(26)	2.20-2
Personal Gear	[53]	2.20-3
Personal Equipment	(12)	2.20-3
Protective Garmets	(25)	2.20-3
Hygenic Equipment	(16)	2.20-3
Life Support	[115]	2.20-4
Food & Packaging	(59)	2.20-4
Recreation Equipment	(3)	2.20-4
Medical and First Aid	(8)	2.20-4
Survival Kit	(45)	2.20-4
Accessories	[25]	2.20-4
Cargo	65000 lb	2.21-2
Residual Fluids	4001 Lb.	
Ascent Propulsion	737	2.23-1
Cruise Propulsion	0	2.23-1
Auxiliary Propulsion	1430	2.23-1
ECS	621	2.23-1
Hydraulic	1087	2.23-1
Misc.	126	2.23-1
Reserve Fluids	13118	
Ascent Propulsion	6486	2.25-1
Cruise Propulsion	0	2.25-1
Maneuver	4720	2.25-1
Attitude Control	1662	2.25-1
ECS	102	2.25-1
Hydraulic	148	2.25-1

		Page No.
Inflight Losses	9788	
Ascent Propulsion	6467	2.26-1
Auxiliary Propulsion	1552	2.26-1
ECS	324	2.26-1
EPS	640	2.26-1
Hydraulic	805	2.26-1
Ascent Propellant	526257	
Main Ascent Propellant	(526257)	2.27-1
Hydrogen	75180	3.3-1
Oxygen	451077	3.3-1
Cruise Propellant	0	
Fuel for Approach and Landing	1140*	2.28-1

*Not included in Easterly or Polar Missions.

Auxiliary Propellant	17510	
Maneuver Propellant	(15847)	3.3-1
Hydrogen	2780	2.29-1
Oxygen	13067	2.29-1
Attitude Control	(1663)	3.3-1
Hydrogen	367	2.29-1
Oxygen	1296	2.29-1

DETAILED WEIGHT STATEMENT

(CANARD BOOSTER)

WING GROUP

57954

		WEIGHT (LB)	PAGE NO.
CARRY THROUGH		[15414]	2.1-16
TORQUE BOX		(15414)	
COVERS - UPPER		6400	
- LOWER		5450	
FRONT SPAR		792	
AFT SPAR		298	
RIBS		1740	
ATTACH, SPLICES, JOINTS		734	
	1/2 WING	FULL WING	
EXPOSED WING	[21270]	[42540]	
LEADING EDGE	(4700)	(9400)	2.1-24
NOSE	1135	2270	
COVERS	1914	3828	
SPAR	377	754	
RIBS	278	556	
FORMERS	644	1288	
ATTACH, SPLICE, JOINTS	352	704	
TORQUE BOX	(13410)	(26820)	2.1-56
COVERS			
SKIN	4654	9308	
STRINGERS	4253	8506	
FRONT SPAR	712	1424	
AFT SPAR	717	1434	
RIBS	1157	2314	
FORMERS	966	1932	
WING-BODY ATTACH	160	320	
FITTINGS	54	108	
ATTACH, SPLICE, JOINT	737	1474	

	WEIGHT (LB)		PAGE NO.
	1/2 WING	FULL WING	
TRAILING EDGE	(445)	(890)	2.1-129
GAP COVER	148	296	
OUTB'D PANEL	97	194	
HINGE FTGS	160	320	
ATTACH, SPLICES	40	80	
INBOARD ELEVON	(1374)	(2748)	2.1-133
COVERS	452	904	
RIBS	168	336	
SPARS	258	516	
FORMERS	92	184	
END PANELS	48	96	
FITTINGS	127	254	
AEROSEAL	50	100	
ATTACH, JOINTS	179	358	
OUTBOARD ELEVON	(1341)	(2682)	2.1-147
COVERS	440	880	
RIBS	170	340	
SPARS	265	530	
FORMERS	92	184	
END PANELS	48	96	
FITTINGS	128	256	
AEROSEAL	46	92	
ATTACH, JOINT, SPLICES	181	362	

TAIL GROUP 19214

		WEIGHT (LB) PER BOOSTER	PAGE NO.
DORSAL FIN	[2,852]	[5,704]	2.2-8
LEADING EDGE	(481)		2.2-14
NOSE	231		
COVERS	133		
SPAR	38		
RIBS	21		
FORMERS	20		
ATTACH, JOINTS	38		
TORQUE BOX	(1,126)		2.2-17
COVERS	493		
SPARS	136		
RIBS	135		
FORMERS	34		
WING ATTACH PROV.	178		
FITTINGS	30		
ATTACH, SPLICE, JOINT	120		
TRAILING EDGE (SUPT/MECH)	(213)		2.2-29
GAP COVER	60		
LOWER PANEL	54		
FITTINGS	80		
ATTACH, SPLICES, JOINTS	19		
RUDDER (STR)	(1,032)		2.2-30
COVERS	305		
RIBS	226		
FORMERS	82		
SPARS	105		
T.E. MEMBER	81		
FITTINGS	95		
ATTACH, JOINTS, SPLICES	138		

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
VENTRAL FIN	[2,865]	[5,730]	2.2-35
LEADING EDGE	(577)		2.2-38
NOSE	308		
COVER	150		
RIBS	34		
FORMERS	15		
SPAR	45		
ATTACH, JOINTS, SPLICE	25		
TORQUE BOX	(1,655)		2.2-47
COVERS	950		
SPARS	195		
RIBS	143		
FORMERS	48		
WING ATTACH PROVISIONS	169		-
ATTACH, SPLICES, JOINTS	150		
TRAILING EDGE	(633)		2.2-58
COVERS	396		
SPAR	73		
RIBS	63		
FORMERS	41		
ATTACH, SPLICE, JOINT	60		
CANARD		[7,780]	2.2-66
TORQUE BOX		(3,944)	
COVERING (UPPER)	(701)		2.2-84
SKIN	332		
STRINGERS	322		
SPLICES, ATTACHMENTS (JSF)	47		
FORWARD SPAR	(716)		
SHEAR WEB	117		
WEB STIFFENERS	253		
CAPS	298		
SPLICES, ATTACHMENTS (JSF)	48		

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
AFT SPAR	(609)		
SHEAR WEB	113		
WEB STIFFENERS	215		
CAPS	235		
SPLICES ATTACHMENTS (JSF)	46		
RIBS (12)	(1,067)		
SHEAR WEB	581		
WEB STIFFENERS (INTEGRAL)	338		
CAPS (INTEGRAL)	67		
FILLETS, BOSSES, ATTACHMENTS	81		
REMOVABLE PANELS (LOWER) (10)	(568)		
STRUCTURE	278		
MECHANISM	290		
TIPS	(211)		
BODY ATTACHMENT	(72)		
UPPER SKIN	5		
FORWARD SPAR CAPS	43		
AFT SPAR CAPS	24		
LEADING EDGE		(1,850)	2.2-97
FORWARD EDGE (HOT)	(423)		
COVER	274		
BEAMS	56		
INSULATION	8		
SEAL	30		
SPLICES, ATTACHMENTS	55		
COVERS	(357)		
SKIN	195		
STRINGERS	87		
STIFFENERS	11		
SPLICES, ATTACHMENTS	64		

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
SPAR	(168)		
WEB	39		
STIFFENERS	10		
CAPS	89		
SPLICES, ATTACHMENTS	30		
RIBS	(130)		
FORMERS	(107)		
INLET LIP (MOVABLE)*	(665)		
FORWARD EDGE (HOT)	254		
COVERS	136		
SPARS	125		
RIBS	71		
RAMPS (ENGINE AIR DUCTS)	25		
SPLICES, ATTACHMENTS	54		
TRAILING EDGE		(380)	2.2-101
COVERS	(165)		
SKIN	95		
STRINGERS	19		
SPLICES, ATTACHMENTS	51		
RIBS	(154)		
FORMERS	(61)		
JET FLAPS (STRUCT) - 10		(1,149)	2.2-107
COVERS	(647)		
SKIN	224		
CORRUGATION	299		
SPLICES, ATTACHMENTS	124		
SPAR	(135)		
WEB	55		
CAPS	54		
SPLICES, ATTACHMENTS	26		

*EXCLUDES HINGE & CONTROL FTGS. WHICH ARE IN ENG. AIR INDUCTION.

TAIL GROUP (CONT'D)

		WEIGHT (LB) PER BOOSTER	PAGE NO.
TRAILING EDGE MEMBER	24		
RIBS	287		
FLAP INTERCONNECTION (FLEX. SKIN)	56		
JET FLAP SUPPORTS		(457)	2.2-112
HINGE FITTINGS	(170)		
CONTROL FITTING	(287)		

148599

ITEM BODY GROUP	WEIGHT-LB.	PAGE NO.
INTEGRAL TANKAGE	102,261	
FUEL TANK (LH_2)	[61,662]	2.3-10
FWD BULKHEAD	(2,631)	
SHELL	1,343	
RESTRAINING RING	970	
WELD LAND	229	
ACCESS DOOR	89	
SIDEWALL	(51,053)	
ISOGRID SIDEWALL	47,757	
WELD LAND	3,050	
WING ATTACH BEEF-UP	44	
ORBITER ATTACH BEEF-UP	202	
AFT BULKHEAD	(3,223)	
SHELL	1,383	
RESTRAINING RING	1,096	
WELD LAND	218	
SUMP	526	
CONTINGENCY - 5%	(2,845)	
BAFFLES	(1,910)	
OXIDIZER TANK (LOX)	[19,769]	2.3-39
FWD BULKHEAD	(300)	
SHELL	124	
RESTRAINING RING	105	
WELD LAND	30	
ACCESS DOOR	41	
SIDEWALL	(9,992)	
ISOGRID SIDEWALL	9,191	
WELD LAND	801	

BODY GROUP (CONT'D)

	WEIGHT-LB.	PAGE NO.
AFT BULKHEAD	(4,107)	
SHELL	2,003	
RESTRAINING RING	1,512	
WELD LAND	257	
SUMP	335	
CONTINGENCY - 5%	(720)	
BAFFLES	(4,650)	
BETWEEN TANKS (INTERTANK)	[16,717]	2.3-60
FWD FRAME	(2,486)	
VERTICAL DIAGONALS	895	
CANTED DIAGONALS	848	
INNER CAP	577	
DIAGONAL ENDS - OUTER	113	
DIAGONAL ENDS - INNER	53	
AFT FRAME	(1,423)	
VERTICAL DIAGONALS	445	
CANTED DIAGONALS	439	
INNER CAP	373	
DIAGONAL ENDS - OUTER	113	
DIAGONAL ENDS - INNER	53	
BOLTED JOINTS	(1,582)	
CIRCUMFERENTIAL JOINTS	1,392	
LONGITUDINAL JOINTS	190	
SIDEWALL	(10,626)	
ISOGRID SIDEWALL	10,240	
ORBITER ATTACH BEEF-UP	386	
CONTINGENCY - 4%	(600)	
INSULATION - FUEL TANK	[4,113]	2.3-84
FUEL TANK INTERNAL INSULATION	(4,113)	
LINER	971	
FOAM	1,785	
BOND	1,357	

BODY GROUP (CONT'D)

	WEIGHT-LB.	PAGE NO.
BASIC STRUCTURE	38,764	
NOSE SECTION SHELL	[967]	2.3-85
THRUST STRUCTURE	[37,797]	2.3-87 & 88
SIDEWALL - STA 3553 - STA 3600	(2,148)	
ISOGRID SIDEWALL	1,733	
JOINT PENALTY - CIRCUMFERENTIAL	399	
JOINT PENALTY - LONGITUDINAL	16	
SIDEWALL - STA 3604 - STA 3710	(4,244)	
ISOGRID SIDEWALL	3,820	
JOINT PENALTY - CIRCUMFERENTIAL	382	
JOINT PENALTY - LONGITUDINAL	42	
SIDEWALL - STA 3714 - STA 3788	(2,891)	
ISOGRID SIDEWALL	2,596	
JOINT PENALTY - CIRCUMFERENTIAL	266	
JOINT PENALTY - LONGITUDINAL	29	
FRAME - STA 3600	(2,686)	
CAP	1,816	
WEB	774	
BRACES	96	
FRAME - STA 3710	(3,722)	
CAP	2,410	
WEB	1,250	
BRACES	62	
FRAME - STA 3792	(4,560)	
CAP	2,957	
WEB	1,538	
BRACES	65	
INBOARD BEAMS AND WEB	(8,660)	
BEAMS	3,643)	
CENTER WEB	3,040	
VERTICAL - OUTBOARD WEB	1,977	

BODY GROUP (CONT'D)

	WEIGHT-LB.	PAGE NO.
LAUNCH LOAD FITTINGS	(3,000)	
UPPER LAUNCH FITTINGS	1,580	
LOWER LAUNCH FITTINGS	692	
LOAD DISTRIBUTION LONGERONS	728	
STIFFENERS AND FITTINGS	(2,544)	
ACTUATOR LOAD STIFFENERS	613	
ENGINE LOAD STIFFENERS	922	
ENGINE MOUNTING FITTINGS	835	
ACTUATOR ATTACH FITTINGS	149	
HEAT SHIELD ATTACH FITTINGS	25	
BOAT TAIL	(4,358)	
SUPPORT TRUSS	851	
EXTERIOR ISOGRID PANELS	2,999	
TRUSS SUPPORT STRUTS	160	
TRUSS SUPPORT BEAMS	248	
BASE HEAT STAND-OFF FITTINGS	100	
REDESIGN OF AFT SKIRT & THRUST STRUC.	(-1,016)	
SECONDARY STRUCTURE	7,574	
CREW COMPARTMENT	[1,920]	2.3-159
FLOOR	(429)	
UPPER PANEL (ISOGRID)	167	
LOWER PANEL (ISOGRID)	102	
CORE (TRUSS)	104	
SIDEWALL ATTACH ANGLES	35	
MISCELLANEOUS & ATTACH PARTS	21	
AFT PRESSURE BULKHEAD	(400)	
FWD PANEL (ISOGRID)	130	
AFT PANEL (ISOGRID)	100	
CORE (TRUSS)	73	
SIDEWALL & FLOOR ATTACH ANGLES	31	
ACCESS DOOR	47	
MISCELLANEOUS & ATTACH PARTS	19	

BODY GROUP (CONT'D)

	WEIGHT-LB	PAGE NO.
FWD PRESSURE BULKHEAD	(85)	
ISOGRID PANEL	68	
SIDEWALL & FLOOR ATTACH ANGLES	13	
MISCELLANEOUS & ATTACH PARTS	4	
LONGITUDINAL PRESSURE PANELS	(78)	
STIFFENED PANEL - LEFT HALF	19	
STIFFENED PANEL - RIGHT HALF	34	
SIDEWALL FORMERS	9	
ATTACH ANGLES (STA 1069 & 1169)	2	
SIDEWALL & FLOOR ATTACH ANGLES	10	
MISCELLANEOUS & ATTACH PARTS	4	
CREW DOOR & JAMB	(176)	
COCKPIT ENCLOSURE	(752)	
WINDSHIELD INSTALLATION	450	
WINDSHIELD THERMAL PROTECTION	302	
DOORS - LANDING GEAR	[1,302]	2.3-170
NOSE GEAR DOOR	(355)	
DOOR	273	
JAMB	72	
MISCELLANEOUS & ATTACH PARTS	10	
MAIN GEAR DOORS	(947)	
DOORS & JAMB	784	
OPERATING MECHANISM	92	
ACTUATION	46	
LOCK MECHANISM	25	
GEAR/WING PROVISIONS	[4,352]	2.3-172
NOSE GEAR WELL	(875)	
SIDE PANELS	537	
COVER	192	
TRUSS	3	
WEB IN FRAMES	61	
MISCELLANEOUS & ATTACH PARTS	56	
CONTINGENCY - 3%	26	

BODY GROUP (CONT'D)

	WEIGHT-LB	PAGE NO.
MAIN GEAR PICKUP	(5,084)	
TRUSS - UPPER HALF - STA 3635	761	
TRUSS - LOWER HALF - STA 3635	548	
CENTER TRUSS - STA 3660	438	
LOAD PICKUP FITTING - STA 3660	80	
TRUSS - UPPER HALF - STA 3685	798	
TRUSS - LOWER HALF - STA 3685	636	
INTERCOSTALS	428	
TRUSS TORQUE BOX PANELS	896	
PANEL SUPPORT ANGLES	37	
MISCELLANEOUS & ATTACH PARTS	462	
MAIN GEAR ENCLOSURE	(647)	
ENCLOSURE PANELS	310	
PANEL SUPPORT ANGLES	157	
PANEL STIFFENERS	107	
DOOR PENALTY	14	
MISCELLANEOUS & ATTACH PARTS	59	
REDESIGN OF MAIN GEAR PICKUP	(-3,377)	
CANARD ATTACH	(578)	
TRUSS - STA 1953	115	
TRUSS - STA 2093	289	
TRUSS BRACES	103	
SHEAR PANEL	54	
MISCELLANEOUS ATTACH PARTS	17	
WIND LEADING EDGE ATTACH	(545)	
"4" FINGER SECTIONS	140	
"2" FINGER SECTIONS	74	
STRUTS	72	
FITTING - INNER HALF	30	
FITTING - OUTER HALF	70	
ATTACH PARTS	40	
SPECIAL FINGER ATTACH PLUGS	99	
MISCELLANEOUS	20	

INDUCED ENVIRONMENT PROTECTION

84807

	SUPT. ITEMS	RAILS	PANELS	WEIGHT (LB)	PAGE NO.
WING				[16450]	2.4-23
STRUCTURE	3073	522	3739	7333	
HCF				5203	
COATING				2459	
BOND				1455	
FIN				[6596]	2.4-24
STRUCTURE	1356	220	1368	2944	
HCF				2035	
COATING				1009	
BOND				608	
CANARD				[4524]	2.4-26
STRUCTURE	876	148	896	1920	
HCF				1489	
COATING				701	
BOND				414	
BODY				[47969]	2.4-27
STRUCTURE	9896	2486	8819	21201	
HCF				14449	
COATING				7626	
BOND				4693	
BASE HEAT PROTECTION				[5678]	2.4-28
BASE HEAT PANELS STA 3862				(3138)	
NOZZLE MOUNTED DISKS				1350	
INTERIOR PANELS				585	
SIDE PANELS				496	
CORNER PANELS				92	
BRUSH SEAL ASSY				615	

	WEIGHT (LB)	PAGE NO.
SUPPORT STRUCTURE	(625)	
MAIN STRUTS	255	
SECONDARY STRUTS	63	
CHANNELS (PANELS)	126	
MAIN STRUT SUPT BRACKET	37	
SEC. STRUT ATTACH FITTINGS	12	
PERIMETER SUPT ANGLE	107	
PANEL EDGE SUPPORT	25	
BOAT TAIL PANELS	(1635)	
ATTACHING PARTS	(280)	
STAND-OFFS	[3327]	2.4-40
INSTRUMENTATION	[263]	2.4-45

NOTE: LEADING EDGES AND NOSE CAP WEIGHT ARE CARRIED IN WING, TAIL AND BODY GROUPS

LANDING AND ORBITER ATTACH	25885		
		WEIGHT (LB)	PAGE NO.
ALIGHTING GEAR	[22590]		2.5-4
MAIN GEAR	15060		2.5-27
ROLLING		(5760)	2.5-46
WHEELS		1456	2.5-46
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BRAKES		2048	2.5-46
AIR		160	2.5-46
STRUCTURE		(8250)	2.5-28
CYLINDER		2290	2.5-28
PISTON		770	2.5-30
AXLE		640	2.5-32
SIDE BRACE		690	2.5-34
FIXED BRACE		250	2.5-36
TORQUE LINKS		390	2.5-38
ATTACH STRUCTURE		2840	2.5-40
INTERNAL PARTS		470	2.5-42
CONTROLS (SYSTEMS)		(1050)	2.5-44
NOSE GEAR	7530		2.5-9
ROLLING		(2880)	2.5-46
WHEELS		728	2.5-46
TIRES		1048	2.5-46
BRAKE		1024	2.5-46
AIR		80	2.5-46

(CONTINUED)

LANDING AND ORBITER ATTACH (CONTINUED)

	WEIGHT (LB)	PAGE NO.
STRUCTURE	(4160)	2.5-10
CYLINDER	1000	2.5-10
PISTON	370	2.5-12
AXLE	370	2.5-14
DRAG LINK	420	2.5-16
TORQUE LINK	230	2.5-18
ATTACH STRUCTURE	620	2.5-20
INTERNAL PARTS	340	2.5-22
STEERING	810	2.5-26
CONTROLS (SYSTEMS)	(490)	2.5-24
ORBITER ATTACH [3295]		2.5-49
AFT ATTACH	(2320)	2.5-51
FORWARD ATTACH	(508)	2.5-64
SEPARATION MECHANISM	(310)	2.5-68
CONTINGENCY (5%)	(157)	

MAIN ASCENT PROPULSION [123320]			
ENGINE & ACCESSORIES [98241]		WEIGHT (LB)	PAGE NO.
ENGINES		(89940)	2.6-5
GIMBAL SYSTEM		(5516)	2.6-6
ACTUATORS		4488	2.6-7
PLUMBING		909	2.6-7
CONTROL WIRING		119	2.6-7
CHILL DOWN SYSTEM		(632)	2.6-8
LO_2 PUMPS		37	2.6-13
LO_2 DUCTS, VALVES & BELLOWS		197	2.6-14
LO_2 SUPPORTS & MISC.		8	2.6-13
LH_2 PUMPS		75	2.6-11
LH_2 DUCTS, VALVES & BELLOWS		200	2.6-12
LH_2 SUPPORTS & MISC.		19	2.6-11
LH_2 DUCT VACUUM JACKET		96	2.6-12
PNEUMATIC SYSTEM		(2129)	2.6-16
HELIUM BOTTLES (DRY)		960	2.6-16
BOTTLE JACKETS & SUPPORTS		188	2.6-16
PLUMBING		685	2.6-21
PLENUMS		100	2.6-18
SUPPORTS, CONTROLS & MISC.		196	2.6-18
HYDRAULIC ENGINE CONTROL		(24)	
PROPELLANT SYSTEM [24579]	LH_2	LO_2	2.6-25
FILL, DRAIN & DUMP	(801)	(690)	
LINES	166	77	2.6-36/36
VALVES & FLANGES	362	362	2.6-34/34
BELLOWS	56	56	2.6-34/34
DISCONNECT	15	15	2.6-34/34
DUMP VENT	42	42	2.6-37/37
SUPPORTS & MISC	160	138	2.6-34/34

(CONTINUED)

(MAIN ASCENT PROPULSION-CONTINUED)

ITEM	LH_2	LO_2	PAGE NO.
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PRESSURIZATION LINES	397	577	2.6-45/41
VALVES & FLANGES	523	523	2.6-45/39
MANIFOLD	61	61	2.6-47/41
GROUND PRESS. & CHECKOUT	7	7	2.6-47/41
VENT DUCT ASSY	222	181	2.6-48/44
DIFFUSSER ASSY	37	37	2.6-48/44
SUPPORTS & MISC.	312	346	2.6-45/39
PROPELLANT LOADING	(40)	(35)	2.6-49
CAPACITANCE PROBE	20	15	2.6-49
POINT LEVEL SENSORS	1	2	2.6-49
ELECTRONICS PACKAGE	3	3	2.6-49
SUPPORT	5	4	2.6-49
WIRING	11	11	2.6-49
FEED SYSTEM	(6031)	(13691)	2.6-50
DUCTS	860	5861	2.6-52
GIMBAL BELLOWS	1062	2884	2.6-53
ISOLATION VALVES	1740	1740	2.6-53
FLANGES	468	468	2.6-53
DUCT INSULATION JACKET	695	0	2.6-62
SUPPORTS & MISC.	1206	2738	2.6-50
CONTINGENCY	[500]		

CRUISE PROPULSION [37053]		
ENGINE & ACCESSORIES [28084]	WEIGHT (LB)	PAGE NO.
ENGINES	(26140)	2.7-4
LEVEL SENSING	(130)	2.7-6
CAPACITANCE PROBES	72	
ELECTRONICS PACKAGE	6	
POINT LEVEL SENSORS	2	
WIRING	42	
SUPPORT	8	
ACCESSORIES	(1814)	2.7-7
INSTRUMENTATION	390	2.7-7
FIRE DETECTION & EXTINGUISHING	210	2.7-7
STARTING SYSTEM	1214	2.7-8
INSTALLATION, DUCTS SHROUDS [3893]		2.7-10
AIR INDUCTION	(1108)	2.7-12
ENGINE MOUNTING	(195)	2.7-16
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EXHAUST SYSTEM	(1600)	2.7-19
PROPELLANT SYSTEM [1428]		2.7-24
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FILL & DRAIN VALVES & DISCONNECT	27	
DUMP VALVES	14	
LINES & FITTINGS	56	
SUPPORTS	8	
FUEL JETTISON CIRCUITRY & CONTROLS	34	

(CRUISE PROPULSION - CONTINUED)

ITEM		WEIGHT (LB)	PAGE NO.
PRESSURIZATION & VENT		(246)	2.7-35
PRESSURIZATION VALVES & XDUCERS		103	
VENT VALVES		42	
VENT BOXES		25	
CIRCUITRY		20	
LINES & FITTINGS		28	
SUPPORTS		28	
BLEED AIR SUPPLY		(46)	2.7-41
VALVES		20	
LINES & FITTINGS		23	
SUPPORTS		3	
PNEUMATIC ACTUATION		(111)	2.7-40
VALVES		86	
LINES & FITTINGS		12	
SUPPORTS		13	
FEED & TRANSFER		(886)	2.7-31
VALVES		168	
PUMPS		180	
LINES & FITTINGS		360	
CIRCUITRY		105	
SUPPORTS & INSTALLATION		73	
TANKAGE-NON INTEGRAL	[2656]		2.7-42
FORWARD TANKS		(1492)	2.7-42
WING TANKS		(1164)	2.7-45
CONTINGENCY	[992]		2.7-46

PROPULSION - AUXILIARY (ACPS)

5396

	FUEL	OXID.	TOTAL WEIGHT	PAGE NO.
THRUSTER INSTALLATION			[549]	
PROPELLANT SYS.	[1112]	[886]	[1998]	
FILL SYS.	(55)	(55)	(110)	2.8-7
VALVES	11	11		
PLUMBING	39	39		
SUPTS.	5	5		
PRESS. SYS.	(74)	(74)	(148)	2.8-9
VALVES	53	53		
PLUMBING	14	14		
SUPTS.	7	7		
VENT SYS.	(108)	(108)	(216)	2.8-11
VALVES	58	58		
PLUMBING	40	40		
SUPTS.	10	10		
FEED SYS.	(875)	(649)	(1524)	2.8-13
VALVES	187	235		
PLUMBING	608	355		
SUPTS	80	59		
TANKAGE	[1344]	[458]	[1802]	
STORAGE	(384)	(126)	(510)	2.8-18
TANK	253	73		
INTERNAL EQUIP.	48	16		
INSULATION	45	13		
SUPPORTS	30	16		
LEVEL INDICATORS	8	8		
ACCUMULATORS	(960)	(332)	(1292)	2.8-31
TANK	778	256		
INSULATION	-	-		
SUPPORTS	182	76		

PROPULSION - AUXILIARY (ACPS) - CONT'D

5396

	FUEL	OXID.	TOTAL WEIGHT	PAGE NO.
CONDITIONING EQUIP.	[450]	[359]	[809]	2.8-32
TURBO-PUMPS	86	139		
HEAT EXCHANGERS	219	148		
GAS GENERATORS	20	20		
SUPPORTS	35	32		
EXHAUST SYS.	70	-		
PLUMBING	20	20		
INSTRUMENTATION			[238]	2.8-34
MEASUREMENTS			186	
SUPPORTS			22	
WIRING			30	

PRIME POWER

3582

	WEIGHT (LB)	PAGE NO.
TANKAGE - STORAGE (COMMON TANKS - CODED TO ACPS)		
TURBO-POWER SYS.	[302]	2.9-7
TURBINES	(176)	
GAS GENERATORS	(22)	
CONTROL LOGIC & INSTRUMENTATION	(68)	
CONTROL VALVES	(36)	
HEAT EXCHANGERS	[173]	2.9-7
RECUPERATORS	(133)	
GEAR BOX COOLERS	(18)	
EQUALIZERS	(22)	
ALTERNATORS	[184]	
DISTRIBUTION SYS.	[295]	2.9-9
LINES & FITTINGS	(32)	
TURBINE EXHAUST LINES	(238)	
VALVES	(12)	
MANIFOLD LINES	(13)	
GEAR BOX ASSY.	[451]	2.9-7
GEAR BOXES	(390)	
LUBE OIL	(61)	
HYDRAULIC PUMPS (CODED TO HYDRAULICS)	-	
AIR BREATHERS - APU	[1816]	2.9-10
POWER UNITS (JP/AIR)	(1156)	
CLUTCHES	(70)	
INLET & EXHAUST DUCTS	(590)	
BATTERY	[35]	2.9-13
SUPPORTS	[326]	2.9-13

ELECTRICAL GROUP

1818

	WEIGHT (LB)	PAGE NO.
POWER CONVERSION EQUIPMENT	[192]	2.10-7
TRANSFORMER RECTIFIERS		
2 KW.	(56)	
1/2 KW.	(16)	
10 KW.	(120)	
POWER CONTROL EQUIPMENT	(484)	2.10-7
POWER CONTRACTORS	(19)	
BUS TIE BREAKERS	(29)	
GENERATOR CONTROL UNITS	(14)	
REMOTE POWER CONTROLLERS	(420)	
BUS VOLTAGE MONITORS	(2)	
POWER DISTRIBUTION CIRCUITS	[853]	2.10-7
WIRE	(742)	
WIRE-POWER MAIN CABLES	604	
WIRE-REMOTE PWR CTR/DIV.	80	
WIRE-CROSS OVER	22	
WIRE-GROUND PWR PROV.	36	
CONNECTORS	(111)	
INSTRUMENTATION	[6]	2.10-7
VOLTAGE READOUTS	(6)	
SUPPORTS	[157]	2.10-7
CLAMPS	(85)	
SUPPORT STRUCTURE	(72)	
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ANTI-COLLISION	(45)	
INTERIOR	(24)	

HYDRAULIC SYSTEM	7,282 WEIGHT (LB)	PAGE NO.
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DISTRIBUTION CONTROL CENTER	(5,879)	2.11-3
RESERVOIRS	1,136	2.11-36
DISTRIBUTION MANIFOLDS	954	2.11-3
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FILTERS	123	2.11-3
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RLS SHUTOFF VALVES	104	2.11-3
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NC RETURN LINE SOL. SHUTOFF VALVES	6	2.11-3
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Total Temp & Press Sensor	10	
Accelerometer	6	
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Pitch Angle of Attack	4	
Sideslip Sensors	4	
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VOR/LOC Receiver	60	
VOR/LOC Antenna	32	
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Radio Altimeter	63	
Radio Altimeter Antenna	6	
Radio Alt Ant Window & Instl	71	
ATC Transponder	20	
ATC Antenna	1	
ATC Ant Window & Instl	13	
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ENVIRONMENTAL CONTROL 2058 LB

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PRESSURE RELIEF VALVE (2)	5	
PRESSURE REGULATOR (2)	4	
SHUT-OFF VALVE (2)	3	
CHECK VALVE (2)	2	
DISCONNECT (2)	1	
TEMP TRANSDUCERS (6)	2	
PRESSURE TRANSDUCERS (9)	12	
AIR	*	
OXYGEN SUPPLY	[33]	
OXYGEN TANK	8	
PRESSURE RELIEF VALVE	3	
PRESSURE REGULATION	2	
SHUT-OFF VALVE	2	
CHECK VALVE (2)	2	
DISCONNECT	1	
MASK CONNECTIONS (2)	1	
FACE MASK AND HOSE (2)	5	
TEMP TRANSDUCERS (3)	1	
PRESSURE TRANSDUCERS (6)	8	
OXYGEN	*	
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*INCLUDED IN RESIDUALS

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WATER SEPARATOR (3)	(7)	
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PRECOOLER ASSY	(9)	
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TEMP CONTROL VALVE	3	
TEMP TRANSDUCERS (4)	1	
PRESSURE TRANSDUCERS (1)	1	
CABIN AIR DISTRIBUTION	(13)	
OVERHEAD DIFFUSER	2	
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LOUVERED OUTLETS (2)	1	
TEMP TRANSDUCERS (3)	1	
PRESSURE TRANSDUCERS (6)	8	
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OUTLET NOZZLE ASSY	9	
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TEMP CONTROL VALVES (2)	(3)	
TEMP CONTROLLER (2)	(4)	
GROUND COOLING ASSY	(9)	
GROUND HEAT EXCHANGER	4	
TEMP CONTROL VALVE	3	
TEMP TRANSDUCERS (2)	1	
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FREON	*	

*INCLUDED IN RESIDUALS

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FLOOR (1" GHF)	29	& 19
FORWARD BULKHEAD (1" GHF)	4	
AFT BULKHEAD (1" GHF)	23	
LOWER SIDEWALL (2" GHF)	29	
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PURGE SYSTEM	816	2.14-23*
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*SEE DISCUSSION ON PAGE 2.14-22

PERSONNEL PROVISIONS 288

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HAND AX	3	
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INST PNL, CONSOLE, PEDESTAL	100	
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COCKPIT LIGHTING	24	
FLOOR COVERING	6	
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* WEIGHT CHARGED TO EC/LS

GROWTH/UNCERTAINTY 42,009

PERSONNEL 522

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RUDDER ACTUATION	232	
JET FLAP ACTUATION	39	
ASCENT ENGINE CONTROL SYSTEM	16	
LANDING SYSTEM (STEERING, BRAKING, GEAR & DOOR ACTUATION)	179	

RESIDUAL & UNEXPENDABLE FLUIDS (CONTINUED)

MISCELLANEOUS	(40)	2.23-5
SERVICE PRESSURANT GH_2	6	
SERVICE PRESSURANT GO_2	1	
SERVICE FUEL LH_2	3	
SERVICE OXIDIZER LO_2	3	
PNEUMATIC SYSTEM HELIUM	27	

RESERVE FLUIDS 10245

	WEIGHT (LB)	PAGE NO.
CRUISE JP-4	(10000)	2.25-3
ATTITUDE CONTROL	(54)	2.25-3
LO_2	48	
LH_2	6	
PRIME POWER "APU"	(191)	2.25-3
LO_2	3	
LH_2	14	
JP-4	174	

INFLIGHT LOSSES & APU PROPELLANT [22847]

	WEIGHT (LB)	PAGE NO.
ASCENT	(20320)	2.26-3
PRESSURANT - GH_2	526	
PRESSURANT - GO_2	366	
TANK RESIDUAL - LH_2	1000	
TANK RESIDUAL - LO_2	1700	
LINE RESIDUAL - LH_2	115	
LINE RESIDUAL - LO_2	1900	
ENGINE RESIDUAL - LH_2	480	
ENGINE RESIDUAL - LO_2	8160	
PU BIAS - LH_2	4841	
CHILLDOWN PROPELLANT - LH_2	20	
CHILLDOWN PROPELLANT - LO_2	360	
SHUTDOWN LOSS - LH_2	324	
SHUTDOWN LOSS - LO_2	528	
ATTITUDE CONTROL	(9)	2.26-4
ACPS PUMP COOLANT - LH_2	5	
ACPS PUMP COOLANT - LO_2	4	
MISCELLANEOUS	(483)	2.26-5
SERVICE PROPELLANT - LH_2	139	
SERVICE PROPELLANT - LO_2	139	
PURGE SYSTEM PENALTY JP-4	137	
PNEUMATIC SYSTEM HELIUM	68	
USABLE APU PROPELLANT	(2035)	2.26-5
LH_2	168	
LO_2	126	
JP-4	1741	

Propellant - Ascent [3 038 600]

Propellant - Cruise [121 000*]

PROPELLANT - ATTITUDE CONTROL SYSTEM [1212]

Appendix B

Alternate Mission Data

B.1 Summary - Space Shuttle requirements were modified during the course of the Phase B activity to establish the 65K payload easterly launched mission from ETR as the design mission. These modified requirements also identify the following reference missions which were considered in our vehicle design.

- o 25K payload, 55 degree inclination resupply mission from ETR (with airbreathing engines in the Orbiter)
- o 40K payload, polar mission from ETR.

As was shown in Section 1 the MDAC design satisfies all these mission requirements.

The resupply and polar missions both presently appear to be slightly more critical than the easterly mission in terms of overall vehicle sizing. The resupply mission sizes the Orbiter auxiliary propellant tank while the polar is most critical from a TPS design standpoint. The booster cruise fuel requirement is determined by the easterly mission, primarily because of the prevailing headwinds for a westerly return to the launch site. No one mission then designs the entire vehicle. Our reporting emphasis has been placed on the easterly mission because it was established by NASA as the design mission.

The three missions are compared in Table B.1-1. The primary mission differences are:

- o Payload differences
- o Airbreathing engines carried only for resupply mission
- o Total velocity required
- o Orbiter maneuvering ΔV required
- o Auxiliary propulsion tanks filled and RL-10 ascent burn for polar mission
- o Differences in booster cruise back range and wind effects

These primary differences lead to other secondary effects such as changes in residual and reserve fluids and growth/uncertainty. Group Weight Statements, Design Data Summaries and sequenced mass propery data for the resupply and polar missions is presented in Sections B.2 and B.3.

TABLE B.1-1 COMPARISON OF SPACE SHUTTLE DESIGN AND REFERENCE MISSIONS

ITEM	EASTERLY	RESUPPLY	POLAR
Vehicle Size	Same	Same	Same
Payload Required	65K	25K	40K
Orbiter Airbreahing Engines Required	No	Yes	No
Total Velocity Required - ft/sec	(29313)	(29823)	(30743)
Booster (Staging)	14991	15098	15201
Orbiter (Nominal)	14032	14430	15238
Flight Performance Reserve	290	295	304
Orbiter Maneuver ΔV Required - ft/sec	900	1500	715
Auxiliary Propulsion Tank Fill-up and RL-10 Ascent Burn Used	No	No	Yes
Booster Cruise Ground Range Required - nm	450	450	439
Total Usable Cruise Fuel Load - Lb	(131000)	(124000)	(112000)
Nominal Fuel*	97000	97000	91000
Reserve Fuel*	34000	27000	11000

*Nominal fuel is based on Booster flyback to launch site with no wind and all engines operating. Total fuel is based on flyback to launch site with design headwinds and one engine out. Reserve fuel is difference between total and nominal.

B.2 Resupply Mission Data - The following data for the resupply mission is presented in this section.

Combined Vehicle Data

Table B.2-1 - Weight Summary (Launch Condition)

Table B.2-2 - Sequenced Mass Properties Summary (Combined Vehicle)

Orbiter Data

Table B.2-3 - Mission Weight Summary

Table B.2-4 - Group Weight Summary

Table B.2-5 - Design Data Statement

Table B.2-6 - Sequenced Mass Properties Summary

Booster Data

Table B.2-7 - Mission Weight Summary

Table B.2-8 - Group Weight Statement

Table B.2-9 - Design Data Statement

Table B.2-10- Sequenced Mass Properties Summary

TABLE B.2-1 WEIGHT SUMMARY (LAUNCH CONDITION) (RESUPPLY MISSION)

CONFIGURATION: CANARD BOOSTER | DELTA ORBITER | BY | DATE

CODE	SYSTEM	ITEM OR MODULE: BOOSTER	EST	CAL	ACT	ORBITER	EST	CAL	ACT
1	WING GROUP	57954				31587			
2	TAIL GROUP	19214				5104			
3	BODY GROUP	148599				55500			
4	INDUCED ENVIR PROTECTION	84807				32847			
5	LANDING, RECOVERY, DOCKING	25885				10551			
6	PROPULSION-ASCENT	123320				26637			
7	PROPULSION-CRUISE	37053				15273			
8	PROPULSION-AUXILIARY	5396				11877			
9	PRIME POWER	3582				2272			
10	ELECT CONVER & DISTR	1818				1303			
11	HYDRA CONVER & DISTR	7282				2760			
12	SURFACE CONTROLS	11320				4901			
13	AVIONICS	4941				4588			
14	ENVIRONMENTAL CONTROL	2058				7849			
15	PERSONNEL PROVISIONS	288				430			
16	RANGE SAFETY & ABORT					0			
17	BALLAST					0			
18	GROWTH UNCERTAINTY	45054				21718			
19									
	SUBTOTAL (DRY WEIGHT)	(578571)				(235197)			
20	PERSONNEL	522				626			
21	CARGO					25000			
22	ORDNANCE					0			
23	RESIDUAL FLUIDS	14567				4205			
24									
	SUBTOTAL (INERT WEIGHT)	(593660)				(265028)			
25	RESERVE FLUIDS	27245				14619			
26	IN FLIGHT LOSSES	22847				9788			
27	PROPELLANT-ASCENT	3038600				526434			
28	PROPELLANT-CRUISE	97000				1140			
29	PROPELLANT-MANEUV ACS	1212				28980			
30									
	TOTAL (GROSS-WEIGHT) LB	(3780564)				(845989)			

DESIGNATIONS:

CLASS OF WEIGHT
EST – PERCENT ESTIMATED WEIGHT
CAL – PERCENT CALCULATED WEIGHT
ACT – PERCENT ACTUAL WEIGHT

NOTES & SKETCHES:
(1) Gross Liftoff Wt = 4626553 Lb.
(2) Weights shown are for the "Analysis Vehicle". Orbiter weights differ from those presented in Report E0403 for the "Final Design Baseline" by the pending changes shown in Table 2-2.

TABLE B.2-2 SEQUENCED MASS PROPERTIES SUMMARY 06/12/71
25K 55 DEG MISSION W/ABES
COMBINED CONFIGURATION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	845988.	2089.	-0.	713.	2586.	42600.	43486.
					-15.	1.	1521.
BOOSTER BO	741964.	3082.	0.	431.	13378.	119894.	127404.
					-48.	3.	7708.
BURN OUT WT	1587951.	2553.	0.	581.	22742.	253401.	255019.
					-35.	-4.	-14652.
ASCENT PROP	759650.	2111.	0.	400.	0.	49800.	49800.
					0.	0.	0.
75% BURN	2347601.	2410.	0.	523.	26387.	328501.	326474.
					-28.	-1.	-5767.
ASCENT PROP	759650.	1938.	0.	400.	0.	36507.	36507.
					0.	0.	0.
50% BURN	3107251.	2205.	0.	493.	28251.	394504.	390614.
					-22.	1.	1408.
ASCENT PROP	759650.	1764.	0.	400.	0.	23195.	23195.
					0.	0.	0.
25% BURN	3866901.	2190.	0.	474.	29382.	455878.	450856.
					-16.	2.	7882.
ASCENT PROP	759650.	1605.	0.	400.	-0.	17496.	17496.
					0.	0.	0.
LAUNCH WT	4626551.	2094.	0.	462.	30141.	521159.	515378.
					-11.	3.	13858.

TABLE B.2-3 MISSION WEIGHT SUMMARY (25K, 55° INCL., RESUPPLY)

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	31587							
2	TAIL GROUP	5104							
3	BODY GROUP	55500							
4	INDUCED ENVIR PROTECTION	32847							
5	LANDING, RECOVERY, DOCKING	10551							
6	PROPULSION-ASCENT	26637							
7	PROPULSION-CRUISE	15273							
8	PROPULSION-AUXILIARY	11877							
9	PRIME POWER	2272							
10	ELECT CONVER & DISTR	1303							
11	HYDRA CONVER & DISTR	2760							
12	SURFACE CONTROLS	4901							
13	AVIONICS	4588							
14	ENVIRONMENTAL CONTROL	7849							
15	PERSONNEL PROVISIONS	430							
16	RANGE SAFETY & ABORT	0							
17	BALLAST	0							
18	GROWTH UNCERTAINTY	21718							
19									
	SUBTOTAL (DRY WEIGHT)	235197							
20	PERSONNEL	626							
21	CARGO	25000							
22	ORDNANCE	0							
23	RESIDUAL FLUIDS	4205							
24									
	SUBTOTAL (INERT WEIGHT)	265028	265028	265028	265028	265028	265028	265028	265028
25	RESERVE FLUIDS	14619	14619	14619	14619	8329	8329	8329	8329
26	IN FLIGHT LOSSES	9788	7826	7816	7383	3250	871	871	0
27	PROPELLANT-ASCENT	526434	526434	263217	0	0	0	0	0
28	PROPELLANT-CRUISE	1140	1140	1140	1140	1140	1140	1140	0
29	PROPELLANT-MANEUV ACS	28980	28980	28980	28980	15451	10429	1000	0
30									
	TOTAL (GROSS-WEIGHT) LB	845989	844027	580800	317150	293198	285797	276368	273357

DESIGNATORS:

EVENTS
A LAUNCH
B IGNITION
C 50% BURN
D INJECTION
E ON-ORBIT
F PRE-RETRO
G ENTRY
H LANDING

NOTES & SKETCHES:

TABLE B.2-4 GROUP WEIGHT STATEMENT (RESUPPLY) PAGE 1 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

1. WING GROUP				31587
	CARRY THROUGH	EXPOSED SURFACE		
BASIC STRUCTURE	( )	( )		
TORQUE BOX				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
VARIABLE GEOMETRY (INCL ____ LBS MECHANISM)				
DOORS, INSULATION, FAIRINGS				
	SURFACE	SUPT/MECH		
CONTROL SURFACES				
AILERONS – (INCL. BAL WT_____LB)				
T.E. FLAPS				
L.E. FLAPS				
SPOILERS				
SPEED BRAKES				
2. TAIL GROUP	VERTICAL	HORIZ		5104
BASIC STRUCTURE	( )	( )		
TORQUE BOX				
CARRY THROUGH				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
	SURFACE	SUPT MECH		
CONTROL SURFACES				
RUDDER INCL. BAL WT_____LB)				
ELEVATOR INCL. BAL WT_____LB)				
3. BODY GROUP				55500
INTEGRAL TANKAGE				
FUEL TANK				
OXIDIZER TANK				
BETWEEN TANKS (CMN BLKHD)				
INSULATION				
BASIC STRUCTURE	FWD. ( )	CTR, ( )	AFT, ( )	SKIRT ( )
SIDEWALLS				
BULKHEADS				
PARTITIONS				
THRUST STRUCTURE (MAIN ASCENT ENGINE)				
SECONDARY STRUCTURE				
CREW COMPARTMENT				
EQUIPMENT COMPARTMENTS				
RADOME ANTENNAS				
SPEED BRAKES				
ENGINE HEAT PROTECTION				
INTERSTAGE				
DOORS FAIRINGS				
GEAR WING PROVISIONS				
CONTINGENCY				

TABLE B.2-4	GROUP WEIGHT STATEMENT (RESUPPLY)			PAGE 2 OF 6
CONFIGURATION	DELTA ORBITER	BY		DATE 15 June 1971

32847

4. INDUCED ENVIRONMENT PROTECTION					
THERMAL PROTECTION	WING	HOR. TAIL	VER. TAIL	BODY	( )
LEADING EDGE /NOSE CAP*	( )	( )	( )	( )	
SURFACE PROTECTION*	( )	( )	( )	( )	
BASE HEAT PROTECTION*				( )	
SOUND PROTECTION					( )
METEORITE /RADIATION PROTECTION					( )

*BREAK OUT BY TYPE OF MATERIAL

TABLE B.2-4 GROUP WEIGHT STATEMENT (RESUPPLY) PAGE 3 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

5. LANDING, DOCKING						10551
ALIGHTING GEAR	ROLLING	STRUCTURE	CONTROLS	7600		
MAIN	3121	2660	843			
NOSE	176	563	237			
DOCKING				400		
AUXILIARY SYSTEMS				1763		
DECELERATION CHUTES			258			
INTERSTAGE ATTACH			627			
PAYLOAD HANDLING/TUNNEL			505/373			
CONTINGENCY				788		
6. PROPULSION – MAIN ASCENT						26637
ENGINE & ACCESSORIES						
ENGINE (AS SUPPLIED)						
GIMBAL SYSTEM						
IGNITION AND CONTROL SYSTEM						
PROPELLANT UTILIZATION SY						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUDS						
PROPELLANT SY		FUEL	OXIDIZER			
FILL DRAIN						
PRESSURIZATION /VENT						
RECIRCULATION						
PCV SY						
PRE-VALVES						
FEED SYSTEMS						
VORTEX, FLOW CONTROL SYSTEM						
TANKAGE – NONINTEGRAL	TANK	INSULATE	SUPTS			
FUEL						
OXIDIZER						
CONTINGENCY						
7. PROPULSION – CRUISE BACK						15273
ENGINE & ACCESSORIES					11282	
ENGINE			10660			
IGNITION AND CONTROL SY			30			
LUBRICATION SY (DRY)			95			
ACCESSORIES			497			
INSTALLATION, DUCTS, SHROUD				2962		
AIR INDUCTION			62			
ENGINE MOUNTING			439			
NACELLES PYLONS INCL 894 LB MECH			2461			
PROPELLANT SY				338		
FILL DRAIN			57			
PRESSURIZATION (DRY)			13			
VENT SY			10			
PUMP			N/A			
FEED SY			163			
TRANSFER SY			47			
DUMP SY			N/A			
SUPPORTS INSTALLATION			48			
TANKAGE – NON INTEGRAL	TANK	INSULATE	SUPTS		175	
FUEL	79	44	52			
CONTINGENCY				516		

TABLE B.2-4 GROUP WEIGHT STATEMENT (RESUPPLY) — PAGE 4 OF 6

CONFIGURATION: DELTA ORBITER — BY: — DATE: 15 JUNE 1971

8. PROPULSION – AUXILIARY				ATT. CONTROL		MANEU-VER	11877
THRUSTER INSTALLATION							
THRUSTER							
ACCESSORY							
PROPELLANT SY							
FILL 'DRAIN							
PRESSURIZATION							
VENT							
FEED SYSTEM							
DUMP SYSTEM							
SUPPORTS							
TANKAGE							
TANKS							
INSULATION							
SUPPORTS							
CONTINGENCY							
9. PRIME POWER	POWER UNIT	MTG INSTAL	PROPEL TANK/SYS	TEMP CONTROL	CON-TROLS	TOTAL	2272
BATTERIES						( )	
ENGINE TURBINE						( )	
FUEL CELL						( )	
10. ELECTRICAL		SUPPLY	CONVER-SION	CONTROL UNITS			1303
EQUIPMENT							
DISTRIBUTION AND CONTROL CIRCUITRY							
UTILITY SYSTEMS							
SUPPORTS/INSTALLATION							
11. HYDRAULIC		PRIMARY ( )	UTILITY ( )	EMERG ( )			2760
POWER SUPPLY							
DISTRIBUTION CONTROL CTR							
TEMPERATURE CONTROL SY							
AUXILIARY SYSTEMS							
SUPPORTS INSTALLATION							
12. SURFACE CONTROLS							4901
COCKPIT CONTROLS							
FLIGHT CONTROL SY		POWER		FEEL	SUPTS	(SEE AVIONICS)	
SYSTEM ACTUATION	CONTROLS ( )	XMISSION ( )	ACTUATOR ( )	SY ( )	INSTALL. ( )		
AILERON							
ELEVATOR							
RUDDER							
T.E FLAP							
SPEED BRAKE							
13. AVIONICS	UNITS ( )	CIRCUITRY ( )	COOLING ( )	ANTENNAS ( )	INSTALL. ( )		4588
GUID NAV							
FLIGHT CONTROL							
DATA MANAGEMENT							
COMMUNICATE							
CONFIG. SEQ,							
INSTRUMENTATION							
DISPLAYS							
CONTINGENCY							

TABLE B.2-4 GROUP WEIGHT STATEMENT (RESUPPLY) — PAGE 5 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

14. ENVIRONMENTAL CONTROL								7849
GAS SUPPLY SYSTEM (DRY)								
GAS MANAGEMENT, PROCESSING (DRY)								
HEAT TRANSPORT SYSTEM (DRY)								
WATER MANAGEMENT SYSTEM (DRY)								
15. PERSONNEL PROVISIONS								430
SEATS 'RESTRAINT SYS (NO =)								
FIXED LIFE SUPPORT EQUIPMENT								
EMERGENCY EQUIPMENT								
CARGO HANDLING								
FURNISHINGS								
16. RANGE SAFETY AND ABORT								0
17. BALLAST								0
18. GROWTH/UNCERTAINTY								21718
19. OPEN								
SUBTOTAL (DRY WEIGHT)								(235197)
20. PERSONNEL	NO	MAN	GARMENTS	HELMET	PRESS. SUIT	ACCESSORIES		626
CREW ( )								
PASSENGER ( )								
PERSONEL GEAR 'ACCESSORIES								
LIFE SUPPORT								
FOOD								
EQUIPMENT – PORTABLE								
21. CARGO								25000
22. ORDNANCE								0
23. RESIDUAL & UNUSABLE FLUIDS								4205
ASCENT							737	
CRUISE							204	
MANEUVER							1430	
ATTITUDE CONTROL							Incl Maneu	
ECS							621	
EPS							0	
HYDRAULIC							1087	
MISC. (SHOCK STRUT, ETC.)							126	
24. OPEN								
SUBTOTAL (INERT WEIGHT)								(265028)

TABLE B.2-4 GROUP WEIGHT STATEMENT — PAGE 6 OF 6

CONFIGURATION	DELTA ORBITER	BY		DATE	15 June 1971

25. RESERVE FLUIDS				14619
ASCENT			6309	
CRUISE			2280	
MANEUVER			4118	
ATTITUDE CONTROL			1662	
ECS			102	
EPS			0	
HYDRAULIC			148	
26. INFLIGHT LOSSES				9788
ASCENT			6467	
CRUISE			0	
MANEUVER			1552	
ATTITUDE CONTROL			Incl Maneu	
ECS			324	
EPS			640	
HYDRAULIC			805	
27. PROPELLANT – ASCENT				526434
28. PROPELLANT – CRUISE				1140
		MANEUV.	ACS	
29. PROPELLANT – MANEUV ACS		27317	1663	28980
TOTAL (GROSS WEIGHT)				(845989)

TABLE B.2-5

DESIGN DATA (DELTA ORBITER)
(25K Resupply Mission)

Pages 1 thru 4 and page 7 are the same as shown for the Easterly Mission in Section 4. Pages 5 and 8 follow.

TABLE B.2-5	DESIGN DATA SUMMARY (RESUPPLY)			PAGE 5 OF 8	
CONFIGURATION	DELTA ORBITER	BY		DATE	15 June

7. PROPULSION – CRUISEBACK

NO. OF ENGINES	4
ENGINE THRUST – S.L. STATIC – LB	Classified
SPECIFIC FUEL CONSUMPTION LB LB – THRUST PER HR	
◦ NOMINAL CRUISE ALTITUDE – FT	Classified
NOMINAL CRUISE ALTITUDE – FT	N/A
NOMINAL CRUISE SPEED – KNOTS	N/A
CRUISE ALTITUDE ENGINE OUT – FT	N/A
CRUISE SPEED, ENGINE OUT – KNOTS	N/A
CRUISE RANGE (ACTUAL REQ) – NA MI	N/A
CRUISE RANGE (MAX AVAIL – NO HEADWIND, ALL ENGINES UP)	N/A
CRUISE LIFT DRAG RATIO	N/A
ENGINE THRUST SIZED BY	APPROACH GO/AROUND ABORT
LIFT COEFFICIENT FOR CRITICAL THRUST CONDITION	.26
LIFT DRAG RATIO	6.5

	TYPE	TANK VOL CU FT	TANK MATL	TANK PRES-PSI	BURST FACTOR	NO. OF TANKS
FUEL SYSTEM	JP	80	Al	30	2	2
PRESSURIZATION SYSTEM	USES MAIN ASCENT PNEUMATIC SYSTEM RESIDUAL GAS					

AIR INTAKE – LENGTH–FT.	2.3
– DIAMETER–FT	3.8
NACELLE WETTED AREA – EACH–SQ FT	131

8. PROPULSION – AUXILIARY

THRUSTERS

THRUST (VAC) – LB	I_{SP} – SEC	ACS	QUANTITY REQ MANEUVER	COMBIN	
15000	444	0	2	0	(2)
1600	379	0	2	0	(2)
1600	360/379	0	0	28	(28)
					( )
					( )

PROPELLANT SYS	TYPE	TANK ** VOLUME	TANK MATL	TANK PRES.PSI	BURST FACTOR	NO. OF TANKS
FUEL	LH_2	2464 FT^3	AL	32	2	1
OXIDIZER	LOX	288.5 FT^3	AL	41	2	2
FUEL PRESSURANT	He	12.1 FT^3	AL	3000	2	1
OXIDIZER PRESS.						

** Net Usable Plus Ullage

9. PRIME POWER	SPECIFIC POWER		TOTAL POWER		TYPE
BATTERIES		WATT-HR LB		WATT-HRS	
ENGINE TURBINE		HP–HR LB FUEL		HP–HR	
		HP–LB OF ENGINE		HP	
FUEL CELL		WATT-HRS LB FUEL		WATT-HRS	
		WATTS LB OF FUEL CELL		WATTS	

TABLE B.2-5 **DESIGN DATA SUMMARY** (RESUPPLY) | PAGE 3 OF 8

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

27 - 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO (BY WEIGHT)	6	N/A	5 & 3.53	5 & 3.53
OXIDIZER ULLAGE VOLUME - PERCENT*	5.5**		25.3	25.3
FUEL ULLAGE VOLUME - PERCENT*	5.5**		15.8	15.8
FUEL DENSITY - PCF	4.395		4.37	4.37
OXIDIZER DENSITY - PCF	71.0		70.6	70.6
FUEL BIAS - PERCENT	.25			
INCREMENTAL VELOCITY - FPS	(14725)		1500	N/A
INERTIAL	14126			
ANGLE OF ATTACK	60			
GRAVITY LOSSES	213			
DRAG LOSSES	2			
BACK PRESSURE LOSSES	29			
FLT. PERFORMANCE RESERVE	295			
RANGE - NA MI		( )		
GROUND MILES				
HEAD WIND ALLOW.				
CONTINGENCY				
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING GO-AROUND-MINUTES				

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES.

** 3% PLUS 1% LOAD ALLOWANCE FOR MIN. I_{SP} LOADING

TABLE B.2-6 SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
25K 55 DEG MISSION W/ABES
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	31587.	1738.	0.	194.	540.	423.	962.
					0.	0.	4.
TAILS	5104.	2054.	0.	632.	2.	11.	11.
					0.	0.	2.
BODY	55500.	1292.	0.	291.	191.	2605.	2551.
					0.	0.	82.
THERMAL PROT	32847.	1353.	-0.	191.	388.	2734.	3095.
					-0.	-0.	-6.
LANDING/DOCK	10551.	1438.	-0.	129.	102.	432.	452.
					-0.	-0.	-36.
PROP-ASCENT	26637.	1863.	4.	320.	42.	416.	395.
					-3.	-1.	3.
PROP-CRUISE	15273.	1593.	1.	123.	219.	36.	237.
					-0.	0.	6.
PROP-AUXIL	11877.	1291.	6.	320.	31.	677.	691.
					-0.	1.	-28.
PRIME POWER	2272.	1015.	-31.	258.	1.	264.	265.
					-12.	-0.	9.
ELEC DIST	1393.	832.	-16.	235.	0.	48.	48.
					-2.	-0.	2.
HYDRA DIST	2760.	1705.	-52.	262.	5.	42.	45.
					-2.	-0.	3.
SURF CONTROL	4901.	1944.	0.	308.	92.	33.	71.
					0.	0.	7.
AVIONICS	4588.	1030.	1.	384.	12.	101.	99.
					1.	-0.	-5.
ENVIR CONTRL	7840.	1124.	0.	363.	0.	90.	74.
					0.	0.	0.
PERSNL PROV	430.	962.	7.	451.	0.	0.	0.
					-0.	-0.	-0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	21718.	1488.	0.	259.	0.	0.	0.
					0.	0.	0.
DRY WEIGHT	235196.	1487.	-0.	259.	2034.	11571.	12260.
					-11.	1.	122.
PERSONNEL	626.	951.	-1.	455.	0.	0.	0.
					-0.	-0.	-0.
LANDED CARGO	25000.	1420.	0.	400.	22.	256.	256.
					0.	0.	0.
RESID FLUIDS	4205.	1389.	0.	282.	22.	253.	239.
					0.	0.	-19.

TABLE B.2-6 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
25K 55 DEG MISSION W/ABES
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
INERT WEIGHT	265027.	1478.	-0.	273.	2180.	12251.	12824.
					-11.	2.	42.
RESERVE FLDS	8329.	1632.	0.	311.	17.	260.	268.
					0.	0.	-23.
LANDING WT	273356.	1483.	-0.	274.	2199.	12554.	13133.
					-11.	2.	23.
CRUISE PROP	1177.	1968.	0.	1004.	-227.	-201.	31.
					0.	0.	-115.
FLIGHT WT	274533.	1485.	-0.	278.	2142.	12583.	13224.
					-11.	2.	9.
ENTRY ACS	1834.	1476.	-0.	323.	-257.	-123.	75.
					-0.	-0.	14.
ENTRY WT	276367.	1485.	-0.	282.	2040.	12624.	13209.
					-11.	2.	20.
RETRO PROP	9429.	1741.	0.	283.	16.	311.	322.
					0.	0.	-27.
PRE RETRO WT	285796.	1493.	-0.	282.	2065.	13064.	13750.
					-11.	2.	-6.
ON ORB LOSS	7401.	1511.	0.	303.	11.	417.	421.
					0.	-0.	-36.
LANDED CARGO	-25000.	1420.	0.	400.	-22.	-256.	-256.
					0.	0.	0.
ASCENT CARGO	25000.	1420.	0.	400.	22.	256.	256.
					0.	0.	0.
ON ORBIT WT	293197.	1494.	-0.	283.	2077.	13482.	14172.
					-11.	2.	-42.
MANEUV PROP	13529.	1741.	0.	283.	23.	446.	462.
					0.	0.	-39.
DUMPED PROP	10423.	812.	0.	228.	5.	82.	87.
					-0.	0.	-0.
INJECTION WT	317140.	1482.	-0.	281.	2110.	15231.	15934.
					-11.	2.	2.

TABLE B.2-6 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
25K 55 DEG MISSION W/ABES
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ASCENT PROP	131304.	997.	0.	228.	103.	1946.	2049.
					0.	0.	-0.
75% BURN	449053.	1339.	-0.	265.	2269.	21970.	22720.
					-12.	1.	517.
ASCENT PROP	131746.	888.	0.	228.	89.	1422.	1510.
					0.	0.	1.
50% BURN	580799.	1237.	-0.	257.	2388.	27895.	28703.
					-13.	1.	886.
ASCENT PROP	131615.	763.	0.	228.	64.	1034.	1098.
					0.	0.	0.
25% BURN	712414.	1149.	-0.	252.	2471.	34156.	35008.
					-14.	1.	1203.
ASCENT PROP	131612.	592.	0.	228.	83.	892.	975.
					-0.	0.	0.
IGNITION	844026.	1063.	-0.	248.	2568.	42505.	43426.
					-15.	1.	1517.
STARTUP	1062.	861.	0.	228.	1.	24.	25.
					0.	0.	0.
LAUNCH WT	845088.	1062.	-0.	248.	2569.	42546.	43468.
					-15.	1.	1519.

TABLE B.2-7 MISSION WEIGHT SUMMARY (RESUPPLY MISSION)

CONFIGURATION | BY | DATE

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	57954							
2	TAIL GROUP	19214							
3	BODY GROUP	148599							
4	INDUCED ENVIR PROTECTION	84807							
5	LANDING, RECOVERY, DOCKING	25885							
6	PROPULSION-ASCENT	123320							
7	PROPULSION-CRUISE	37053							
8	PROPULSION-AUXILIARY	5396							
9	PRIME POWER	3582							
10	ELECT CONVER & DISTR	1818							
11	HYDRA CONVER & DISTR	7282							
12	SURFACE CONTROLS	11320							
13	AVIONICS	4941							
14	ENVIRONMENTAL CONTROL	2058							
15	PERSONNEL PROVISIONS	288							
16	RANGE SAFETY & ABORT								
17	BALLAST								
18	GROWTH UNCERTAINTY	45054							
19									
	SUBTOTAL DRY WEIGHT	(578571)							
20	PERSONNEL	522							
21	CARGO								
22	ORDNANCE								
23	RESIDUAL FLUIDS	14567							
24									
	SUBTOTAL INERT WEIGHT	(593660)							
25	RESERVE FLUIDS	27245	27245	27245	27245	27245	245		
26	IN FLIGHT LOSSES	22847	22847	22847	2035				
27	PROPELLANT-ASCENT	3038600	1519300						
28	PROPELLANT-CRUISE	97000	97000	97000	97000	10000	10000		
29	PROPELLANT-MANEUV ACS	1212	1212	1212					
30									
	TOTAL GROSS-WEIGHT LB	3780564	2261264	741964	719940	630905	603905		

DESIGNATORS

EVENTS
A LAUNCH WEIGHT
B 50% BURN
C BURNOUT
D START CRUISE
E END CRUISE
F LANDING
G
H

NOTES & SKETCHES:

(RESUPPLY)

TABLE B.2-8 GROUP WEIGHT STATEMENT — PAGE 1 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

1. WING GROUP				57954
	CARRY THROUGH	EXPOSED SURFACE		
BASIC STRUCTURE	( )	( )		
TORQUE BOX				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
VARIABLE GEOMETRY (INCL ____ LBS MECHANISM)				
DOORS, INSULATION, FAIRINGS				
CONTROL SURFACES	SURFACE	SUPT/MECH		
AILERONS – (INCL. BAL WT_____LB)				
T.E. FLAPS				
L.E. FLAPS				
SPOILERS				
SPEED BRAKES				
2. TAIL GROUP	VERTICAL	HORIZ		19214
BASIC STRUCTURE	( )	( )		
TORQUE BOX				
CARRY THROUGH				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
CONTROL SURFACES	SURFACE	SUPT MECH		
RUDDER (INCL. BAL WT_____LB)				
ELEVATOR (INCL. BAL WT_____LB)				
3. BODY GROUP				148599
INTEGRAL TANKAGE				
FUEL TANK				
OXIDIZER TANK				
BETWEEN TANKS (CMN BLKHD)				
INSULATION				
BASIC STRUCTURE	FWD. ( )	CTR, ( )	AFT, ( )	SKIRT ( )
SIDEWALLS				
BULKHEADS				
PARTITIONS				
THRUST STRUCTURE (MAIN ASCENT ENGINE)				
SECONDARY STRUCTURE				
CREW COMPARTMENT				
EQUIPMENT COMPARTMENTS				
RADOME/ANTENNAS				
SPEED BRAKES				
ENGINE HEAT PROTECTION				
INTERSTAGE (INCL. MECH._____LBS)				
DOORS/FAIRINGS				
GEAR/WING PROVISIONS				
CONTINGENCY				

NOTE: SUBSYSTEM DETAILS ARE LISTED ONLY WHERE SUBSYSTEM TOTAL IS DIFFERENT THAN FOR EASTERLY MISSION.

(RESUPPLY)

TABLE B.2-8 GROUP WEIGHT STATEMENT				PAGE 2 OF 6	
CONFIGURATION	CANARD BOOSTER	BY		DATE	15 June 1971

84807

4. INDUCED ENVIRONMENT PROTECTION

	WING	HOR. TAIL	VER. TAIL	BODY	( )
THERMAL PROTECTION					
LEADING EDGE/NOSE CAP*	( )	( )	( )	( )	
SURFACE PROTECTION*	( )	( )	( )	( )	
BASE HEAT PROTECTION*				( )	
SOUND PROTECTION					( )
METEORITE/RADIATION PROTECTION					( )

*BREAK OUT BY TYPE OF MATERIAL

(RESUPPLY)

TABLE B.2-8 GROUP WEIGHT STATEMENT — PAGE 3 OF 6

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 June 1971

5. LANDING, DOCKING						25885
ALIGHTING GEAR		ROLLING	STRUCTURE	CONTROLS		
MAIN						
NOSE						
DOCKING						
AUXILIARY SYSTEMS						
DECELERATION CHUTES						
FLOTATION GEAR						
HANDLING GEAR						
CONTINGENCY						123320
6. PROPULSION – MAIN ASCENT						
ENGINE & ACCESSORIES						
ENGINE (AS SUPPLIED)						
GIMBAL SYSTEM						
IGNITION AND CONTROL SYSTEM						
PROPELLANT UTILIZATION SY						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUDS						
PROPELLANT SY			FUEL	OXIDIZER		
FILL DRAIN						
PRESSURIZATION						
VENT SY						
PCV SY						
PRE-VALVES						
FEED SYSTEMS						
VORTEX, FLOW CONTROL SYSTEM						
SUPPORTS AND INSTALL						
TANKAGE – NONINTEGRAL		TANK	INSULATE	SUPTS		
FUEL						
OXIDIZER						37053
CONTINGENCY						
7. PROPULSION – CRUISE BACK						
ENGINE & ACCESSORIES						
ENGINE						
IGNITION AND CONTROL SY						
LUBRICATION SY (DRY)						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUD						
AIR INDUCTION						
ENGINE MOUNTING						
NACELLES PYLONS INCL _____ LB MECH)						
EXHAUST SY						
PROPELLANT SY						
FILL DRAIN						
PRESSURIZATION (DRY)						
VENT SY						
PUMP						
FEED SY						
TRANSFER SY						
DUMP SY						
SUPPORTS/INSTALLATION						
TANKAGE – NON INTEGRAL		TANK	INSULATE	SUPTS		
FUEL						
CONTINGENCY						

(RESUPPLY)

TABLE B.2-8 GROUP WEIGHT STATEMENT — PAGE 4 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

8. PROPULSION – AUXILIARY			ATT. CONTROL		MANEU-VER		5396
THRUSTER INSTALLATION							
THRUSTER							
ACCESSORY							
PROPELLANT SY							
FILL 'DRAIN							
PRESSURIZATION							
VENT							
FEED SYSTEM							
DUMP SYSTEM							
SUPPORTS							
TANKAGE							
TANKS							
INSULATION							
SUPPORTS							
CONTINGENCY							
9. PRIME POWER	POWER UNIT	MTG INSTAL	PROPEL TANK/SYS	TEMP CONTROL	CON-TROLS	TOTAL	3582
BATTERIES						( )	
ENGINE TURBINE						( )	
FUEL CELL						( )	
10. ELECTRICAL		SUPPLY	CONVER-SION	CONTROL UNITS			1818
EQUIPMENT							
DISTRIBUTION AND CONTROL CIRCUITRY							
UTILITY SYSTEMS							
SUPPORTS/INSTALLATION							
11. HYDRAULIC		PRIMARY ( )	UTILITY ( )	EMERG ( )			7282
POWER SUPPLY							
DISTRIBUTION CONTROL CTR							
TEMPERATURE CONTROL SY							
AUXILIARY SYSTEMS							
SUPPORTS INSTALLATION							
12. SURFACE CONTROLS							11320
COCKPIT CONTROLS							
FLIGHT CONTROL SY		POWER		FEEL	SUPTS	(SEE AVIONICS)	
SYSTEM ACTUATION	CONTROLS ( )	XMISSION ( )	ACTUATOR ( )	SY ( )	INSTALL. ( )		
AILERON							
ELEVATOR							
RUDDER							
T.E FLAP							
SPEED BRAKE							
13. AVIONICS	UNITS ( )	CIRCUITRY ( )	COOLING ( )	ANTENNAS ( )	INSTALL. ( )		4941
GUID NAV							
FLIGHT CONTROL							
DATA MANAGEMENT							
COMMUNICATE							
CONFIG. SEQ,							
INSTRUMENTATION							
DISPLAYS							
CONTINGENCY							

(RESUPPLY)

TABLE B.2-8 GROUP WEIGHT STATEMENT — PAGE 5 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

14. ENVIRONMENTAL CONTROL			2058
GAS SUPPLY SYSTEM (DRY)			
GAS MANAGEMENT, PROCESSING (DRY)			
HEAT TRANSPORT SYSTEM (DRY)			
WATER MANAGEMENT SYSTEM (DRY)			
15. PERSONNEL PROVISIONS			288
SEATS 'RESTRAINT SYS (NO =)			
FIXED LIFE SUPPORT EQUIPMENT			
EMERGENCY EQUIPMENT			
CARGO HANDLING			
FURNISHINGS			
16. RANGE SAFETY AND ABORT			0
17. BALLAST			0
18. GROWTH/UNCERTAINTY			45054
19. OPEN			
SUBTOTAL (DRY WEIGHT)			(578571)
20. PERSONNEL (NO, MAN, GARMENTS, HELMET, PRESS. SUIT, ACCESSORIES)			522
CREW			
PASSENGER ( )			
PERSONEL GEAR 'ACCESSORIES			
LIFE SUPPORT			
FOOD			
EQUIPMENT – PORTABLE			
21. CARGO			0 0
22. ORDNANCE			
23. RESIDUAL & UNUSABLE FLUIDS			14567
ASCENT		4796	
CRUISE		3905	
MANEUVER		0	
ATTITUDE CONTROL		306	
ECS		84	
APU		55	
HYDRAULIC		5381	
MISCELLANEOUS		40	
24. OPEN			0
SUBTOTAL (INERT WEIGHT)			(593660)

(RESUPPLY)

TABLE B.2-8 GROUP WEIGHT STATEMENT				PAGE 6 OF 6
CONFIGURATION	CANARD BOOSTER	BY	DATE	15 June 1971

			27245
25. RESERVE FLUIDS			
ASCENT		0	
CRUISE		27000	
MANEUVER		0	
ATTITUDE CONTROL		54	
ECS		0	
APU		191	
HYDRAULIC		0	
			22847
26. INFLIGHT LOSSES			
ASCENT			
CRUISE			
MANEUVER			
ATTITUDE CONTROL			
ECS			
EPS			
HYDRAULIC			
			3038600
27. PROPELLANT – ASCENT			
			97000
28. PROPELLANT – CRUISE			
	MANEUV.	ACS	
			1212
29. PROPELLANT – MANEUV ACS			
			(3780564)
TOTAL (GROSS WEIGHT)			

TABLE B.2-9

DESIGN DATA SUMMARY

(CANARD BOOSTER, RESUPPLY MISSION)

Pages 1 thru 7 of Design Data Summary are the same as for Easterly Mission except Growth/Uncertainty which changes from 42009 to 45054 lb. The ΔV's on page 8 are revised as shown on the following page.

TABLE B.2-9 DESIGN DATA SUMMARY				PAGE 8 OF 8
CONFIGURATION	CANARD BOOSTER	BY		DATE 15 June 1971

(25K, 55° RESUPPLY MISSION W/ABES)

27 - 29 PROPELLANTS EXPENDED	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO				
(BY WEIGHT)				
OXIDIZER ULLAGE VOLUME - PERCENT*				
FUEL ULLAGE VOLUME - PERCENT*				
FUEL DENSITY – PCF				
OXIDIZER DENSITY – PCF				
FUEL BIAS – PERCENT				
INCREMENTAL VELOCITY – FPS	(15098)			
INERTIAL	10927			
ANGLE OF ATTACK	38			
GRAVITY LOSSES	3350			
DRAG LOSSES	515			
BACK PRESSURE LOSSES	268			
FLT. PERFORMANCE RESERVE				
RANGE – NA MI		(605)		
GROUND MILES		453		
HEAD WIND /ENGINE OUT ALLOW.		152		
CONTINGENCY				
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING GO-AROUND–MINUTES		5.1		

* BASED ON NOMINAL LOADING INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES.

NOTE: ABES = ORBITER AIRBREATHING ENGINE SYSTEM

TABLE B.2-10 SEQUENCED MASS PROPERTIES SUMMARY 06/16/71
CANARD BOOSTER 55 DEG MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	57054.	3797.	0.	599.	2638.	244.	2809.
					0.	0.	16.
TAIL&CANARD	19214.	3278.	0.	475.	2466.	4689.	6714.
					0.	0.	389.
BODY	148599.	2816.	0.	395.	985.	20749.	20719.
					0.	0.	-109.
THERMAL PROT	84807.	3053.	0.	441.	3071.	14592.	16806.
					0.	0.	1124.
LANDING GEAR	25885.	3098.	0.	286.	153.	3035.	2960.
					0.	0.	-28.
ASCENT PROP	123320.	3708.	0.	439.	274.	4796.	4767.
					5.	0.	-235.
CRUISE PROP	37053.	2111.	0.	249.	235.	1196.	1302.
					1.	0.	203.
ORIENT SYS	5396.	2331.	14.	546.	8.	447.	453.
					-5.	0.	-1.
SURF CONTROL	11320.	3851.	0.	618.	883.	465.	1271.
					0.	0.	109.
PRIME POWER	3582.	3654.	0.	281.	1.	22.	22.
					0.	0.	0.
ELEC CON/DIS	1918.	2299.	0.	507.	2.	35.	34.
					0.	0.	4.
HYDRAULICS	7282.	3709.	0.	409.	4.	16.	16.
					0.	0.	0.
AVIONICS	4941.	1838.	0.	429.	5.	938.	937.
					0.	0.	9.
LAUNCH ESC	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
ECLS	2059.	2352.	0.	435.	6.	482.	477.
					0.	0.	14.
PERS PROV	288.	1120.	0.	423.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
PEND CHGS	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH	45054.	3095.	0.	420.	97.	3501.	3501.
					0.	0.	0.
DRY WT	578571.	3163.	0.	426.	11732.	87414.	94090.
					-14.	2.	5388.
PERSONNEL	522.	1110.	0.	425.	0.	0.	0.
					0.	0.	0.
RESIDUALS	14567.	2845.	2.	421.	129.	2950.	3010.
					-4.	1.	48.

TABLE B.2-10 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/16/71
CANARD BOOSTER 55 DEG MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
RESERVE	10245.	3801.	0.	599.	540.	172.	711.
					-1.	-0.	6.
LANDING WT	603305.	3165.	0.	429.	12466.	92294.	99504.
					-21.	3.	5690.
CRU RESR DMP	27000.	3845.	0.	600.	0.	0.	0.
					0.	0.	0.
END OF CRUSE	630905.	3194.	0.	436.	12629.	95040.	102087.
					-22.	3.	6340.
CRU PRO USED	87000.	2257.	0.	400.	715.	7096.	7588.
					0.	0.	882.
APU PROP	2035.	2023.	6.	540.	0.	-0.	0.
					0.	0.	0.
CRUISE START	719940.	3077.	0.	432.	13372.	117122.	124635.
					-22.	3.	7737.
INFLT LOSS	20812.	3313.	1.	402.	1.	2214.	2213.
					-4.	0.	-11.
ORIENT PROP	1212.	2023.	82.	400.	0.	0.	0.
					0.	0.	0.
PEND CHNGS	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BURN OUT WT	741964.	3082.	0.	431.	13379.	119877.	127386.
					-48.	3.	7704.
ASCENT PROP	759650.	2111.	0.	400.	0.	49800.	49800.
					0.	0.	0.
75% BURN	1501614.	2591.	0.	415.	13458.	246127.	253558.
					-22.	4.	10154.
ASCENT PROP	759650.	1938.	0.	400.	0.	36507.	36507.
					0.	0.	0.
50% BURN	2261264.	2371.	0.	410.	13484.	329113.	336517.
					-11.	4.	11249.
ASCENT PROP	759650.	1764.	0.	400.	0.	23195.	23195.
					0.	0.	0.

TABLE B.2-10 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/16/71
CANARD BOOSTER 55 DEG MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
25% BURN	3020914.	2219.	0.	408.	13497.	397570.	404962.
					-3.	4.	12010.
ASCENT PROP	759650.	1605.	0.	400.	-0.	17496.	17496.
					0.	0.	0.
LAUNCH WT	3780564.	2095.	0.	406.	13504.	464500.	471884.
					3.	4.	12626.

B.3 Polar Mission Data - The following data for the polar mission is presented in this section.

Combined Vehicle Data

Table B.3-1 - Weight Summary (Launch Condition)

Table B.3-2 - Sequenced Mass Properties Summary (Combined Vehicle)

Orbiter Data

Table B.3-3 - Mission Weight Summary

Table B.3-4 - Group Weight Statement

Table B.3-5 - Design Data Statement

Table B.3-6 - Sequenced Mass Properties Summary

Booster Data

Table B.3-7 - Mission Weight Summary

Table B.3-8 - Group Weight Statement

Table B.3-9 - Design Data Statement

Table B.3-10- Sequenced Mass Properties Summary

TABLE B.3-1 WEIGHT SUMMARY (LAUNCH CONDITION) (POLAR MISSION)

CONFIGURATION	CANARD BOOSTER	DELTA ORBITER	BY		DATE			
CODE	SYSTEM	ITEM OR MODULE						
		BOOSTER	EST	CAL	ACT	ORBITER	EST	CAL	ACT
1	WING GROUP	57954				31587			
2	TAIL GROUP	19214				5104			
3	BODY GROUP	148599				55500			
4	INDUCED ENVIR PROTECTION	84807				32847			
5	LANDING, RECOVERY, DOCKING	25885				10551			
6	PROPULSION-ASCENT	123320				26637			
7	PROPULSION-CRUISE	37053				574			
8	PROPULSION-AUXILIARY	5396				11877			
9	PRIME POWER	3582				2272			
10	ELECT CONVER & DISTR	1818				1303			
11	HYDRA CONVER & DISTR	7282				2760			
12	SURFACE CONTROLS	11320				4901			
13	AVIONICS	4941				4588			
14	ENVIRONMENTAL CONTROL	2058				7849			
15	PERSONNEL PROVISIONS	288				430			
16	RANGE SAFETY & ABORT					0			
17	BALLAST					0			
18	GROWTH UNCERTAINTY	42483				23086			
19									
	SUBTOTAL (DRY WEIGHT)	(576000)				(221866)			
20	PERSONNEL	522				626			
21	CARGO					40000			
22	ORDNANCE					0			
23	RESIDUAL FLUIDS	14127				4001			
24									
	SUBTOTAL (INERT WEIGHT)	(590649)				(266493)			
25	RESERVE FLUIDS	11245				16178			
26	IN FLIGHT LOSSES	22847				9788			
27	PROPELLANT-ASCENT	3038600				548927			
28	PROPELLANT-CRUISE	91000				0			
29	PROPELLANT-MANEUV ACS	1212				12022			
30	OMS FILLUP INCREMENT								
	ORBITER STARTUP								
	TOTAL (GROSS-WEIGHT) LB	(3755553)				(853408)			

DESIGNATIONS:

CLASS OF WEIGHT
EST – PERCENT ESTIMATED WEIGHT
CAL – PERCENT CALCULATED WEIGHT
ACT – PERCENT ACTUAL WEIGHT

NOTES & SKETCHES:

(1) Gross Liftoff Wt = 4608961 Lb
(2) Weights shown are for the "Analysis Vehicle". Orbiter weights differ from those presented in Report E0403 for the "Final Design Baseline" by the pending changes shown in Table 2-2.

TABLE B.3-2 SEQUENCED MASS PROPERTIES SUMMARY 06/12/71
40K POLAR MISSION
COMBINED CONFIGURATION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	853407.	2093.	-0.	717.	2483.	43331.	44044.
					-14.	1.	1791.
BOOSTER BO	716953.	3074.	0.	428.	13267.	116011.	123626.
					-47.	3.	7172.
BURN OUT WT	1570360.	2541.	0.	585.	22777.	247373.	248676.
					-34.	-4.	-14894.
ASCENT PROP	759650.	2111.	0.	400.	0.	49800.	49800.
					0.	0.	0.
75% BURN	2330010.	2401.	0.	525.	26560.	321387.	318906.
					-27.	-1.	-6103.
ASCENT PROP	759650.	1938.	0.	400.	0.	36507.	36507.
					0.	0.	0.
50% BURN	3089660.	2287.	0.	494.	28483.	386348.	381944.
					-21.	1.	1040.
ASCENT PROP	759650.	1764.	0.	400.	0.	23195.	23195.
					0.	0.	0.
25% BURN	3849310.	2184.	0.	475.	29647.	446671.	441103.
					-16.	2.	7509.
ASCENT PROP	759650.	1605.	0.	400.	-0.	17496.	17496.
					0.	0.	0.
LAUNCH WT	4608960.	2088.	0.	463.	30427.	510901.	504553.
					-11.	3.	13497.

TABLE B.3-3 MISSION WEIGHT SUMMARY (POLAR)

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	31587							
2	TAIL GROUP	5104							
3	BODY GROUP	55500							
4	INDUCED ENVIR PROTECTION	32847							
5	LANDING, RECOVERY, DOCKING	10551							
6	PROPULSION-ASCENT	26637							
7	PROPULSION-CRUISE	574							
8	PROPULSION-AUXILIARY	11877							
9	PRIME POWER	2272							
10	ELECT CONVER & DISTR	1303							
11	HYDRA CONVER & DISTR	2760							
12	SURFACE CONTROLS	4901							
13	AVIONICS	4588							
14	ENVIRONMENTAL CONTROL	7849							
15	PERSONNEL PROVISIONS	430							
16	RANGE SAFETY & ABORT	0							
17	BALLAST	0							
18	GROWTH UNCERTAINTY	23086							
19									
	SUBTOTAL (DRY WEIGHT)	221866							
20	PERSONNEL	626							
21	CARGO	40000							
22	ORDNANCE	0							
23	RESIDUAL FLUIDS	4001							
24									
	SUBTOTAL (INERT WEIGHT)	266493	266493	266493	266493	266493	266493	266493	266493
25	RESERVE FLUIDS	16178	16178	16178	16178	10013	10013	10013	10013
26	IN FLIGHT LOSSES	9788	7826	7816	7383	3250	871	871	0
27	PROPELLANT-ASCENT	548927	548927	278899	0	0	0	0	0
28	PROPELLANT-CRUISE	0	0	0	0	0	0	0	0
29	PROPELLANT-MANEUV ACS	12022	12022	12022	12022	10257	5901	1000	0
30									
	TOTAL (GROSS-WEIGHT) LB	853408	851446	581408	302076	290013	283278	278377	276506

DESIGNATORS:

EVENTS
A Launch
B Ignition (Effective)
C 50% Burn
D Injection
E On-Orbit
F Pre-Retro
G Entry
H Landing

NOTES & SKETCHES:

TABLE B.3-4 GROUP WEIGHT STATEMENT (POLAR) PAGE 1 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

1. WING GROUP				31587
	CARRY THROUGH	EXPOSED SURFACE		
BASIC STRUCTURE	( )	( )		
TORQUE BOX				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
VARIABLE GEOMETRY (INCL ____ LBS MECHANISM)				
DOORS, INSULATION, FAIRINGS				
CONTROL SURFACES	SURFACE	SUPT/MECH		
AILERONS – (INCL. BAL WT_____LB)				
T.E. FLAPS				
L.E. FLAPS				
SPOILERS				
SPEED BRAKES				
2. TAIL GROUP	VERTICAL	HORIZ		5104
BASIC STRUCTURE	( )	( )		
TORQUE BOX				
CARRY THROUGH				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
CONTROL SURFACES	SURFACE	SUPT MECH		
RUDDER (INCL. BAL WT_____LB)				
ELEVATOR (INCL. BAL WT_____LB)				
3. BODY GROUP				55500
INTEGRAL TANKAGE				
FUEL TANK				
OXIDIZER TANK				
BETWEEN TANKS (CMN BLKHD)				
INSULATION				
BASIC STRUCTURE	FWD. ( )	CTR, ( )	AFT, ( )	SKIRT ( )
SIDEWALLS				
BULKHEADS				
PARTITIONS				
THRUST STRUCTURE (MAIN ASCENT ENGINE)				
SECONDARY STRUCTURE				
CREW COMPARTMENT				
EQUIPMENT COMPARTMENTS				
RADOME ANTENNAS				
SPEED BRAKES				
ENGINE HEAT PROTECTION				
INTERSTAGE (INCL. MECH._____LBS)				
DOORS FAIRINGS				
GEAR WING PROVISIONS				
CONTINGENCY				

TABLE B.3-4 GROUP WEIGHT STATEMENT (POLAR)				PAGE 2 OF 6
CONFIGURATION	DELTA ORBITER	BY		DATE 15 June 1971

32847

4. INDUCED ENVIRONMENT PROTECTION

	WING	HOR. TAIL	VER. TAIL	BODY	( )
THERMAL PROTECTION					
LEADING EDGE NOSE CAP*	( )	( )	( )	( )	
SURFACE PROTECTION*	( )	( )	( )	( )	
BASE HEAT PROTECTION*				( )	
SOUND PROTECTION					( )
METEORITE RADIATION PROTECTION					( )

*BREAK OUT BY TYPE OF MATERIAL

TABLE B.3-4 GROUP WEIGHT STATEMENT (POLAR) PAGE 3 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

5. LANDING, DOCKING						10551
ALIGHTING GEAR		ROLLING	STRUCTURE	CONTROLS		
MAIN						
NOSE						
DOCKING						
AUXILIARY SYSTEMS						
DECELERATION CHUTES						
FLOTATION GEAR						
HANDLING GEAR						
CONTINGENCY						26637
6. PROPULSION – MAIN ASCENT						
ENGINE & ACCESSORIES						
ENGINE (AS SUPPLIED)						
GIMBAL SYSTEM						
IGNITION AND CONTROL SYSTEM						
PROPELLANT UTILIZATION SY						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUDS						
PROPELLANT SY			FUEL	OXIDIZER		
FILL DRAIN						
PRESSURIZATION						
VENT SY						
PCV SY						
PRE-VALVES						
FEED SYSTEMS						
VORTEX, FLOW CONTROL SYSTEM						
SUPPORTS AND INSTALL						
TANKAGE – NONINTEGRAL	TANK	INSULATE	SUPTS			
FUEL						
OXIDIZER						
CONTINGENCY						574
7. PROPULSION – CRUISE BACK						
ENGINE & ACCESSORIES						
ENGINE						
IGNITION AND CONTROL SY						
LUBRICATION SY (DRY)						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUD						
AIR INDUCTION						
ENGINE MOUNTING						
NACELLES PYLONS INCL _____ LB MECH)						
EXHAUST SY						
PROPELLANT SY						
FILL DRAIN						
PRESSURIZATION (DRY)						
VENT SY						
PUMP						
FEED SY						
TRANSFER SY						
DUMP SY						
SUPPORTS 'INSTALLATION						
TANKAGE – NON INTEGRAL	TANK	INSULATE	SUPTS			
FUEL						
CONTINGENCY						

TABLE B.3-4 GROUP WEIGHT STATEMENT (POLAR) | PAGE 4 OF 6

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

8. PROPULSION – AUXILIARY				ATT. CONTROL		MANEU-VER	11877
THRUSTER INSTALLATION							
THRUSTER							
ACCESSORY							
PROPELLANT SY							
FILL/DRAIN							
PRESSURIZATION							
VENT							
FEED SYSTEM							
DUMP SYSTEM							
SUPPORTS							
TANKAGE							
TANKS							
INSULATION							
SUPPORTS							
CONTINGENCY							
9. PRIME POWER	POWER UNIT	MTG INSTAL	PROPEL TANK/SYS	TEMP CONTROL	CON-TROLS	TOTAL	2272
BATTERIES						( )	
ENGINE TURBINE						( )	
FUEL CELL						( )	
10. ELECTRICAL		SUPPLY	CONVER-SION	CONTROL UNITS			1303
EQUIPMENT							
DISTRIBUTION AND CONTROL CIRCUITRY							
UTILITY SYSTEMS							
SUPPORTS/INSTALLATION							
11. HYDRAULIC		PRIMARY ( )	UTILITY ( )	EMERG ( )			2760
POWER SUPPLY							
DISTRIBUTION CONTROL CTR							
TEMPERATURE CONTROL SY							
AUXILIARY SYSTEMS							
SUPPORTS INSTALLATION							
12. SURFACE CONTROLS							4901
COCKPIT CONTROLS							
FLIGHT CONTROL SY						(SEE AVIONICS)	
SYSTEM ACTUATION	CONTROLS ( )	POWER XMISSION ( )	ACTUATOR ( )	FEEL SY ( )	SUPTS INSTALL. ( )		
AILERON							
ELEVATOR							
RUDDER							
T.E. FLAP							
SPEED BRAKE							
13. AVIONICS	UNITS ( )	CIRCUITRY ( )	COOLING ( )	ANTENNAS ( )	INSTALL. ( )		4588
GUID NAV							
FLIGHT CONTROL							
DATA MANAGEMENT							
COMMUNICATE							
CONFIG. SEQ.							
INSTRUMENTATION							
DISPLAYS							
CONTINGENCY							

TABLE B.3-4	GROUP WEIGHT STATEMENT (POLAR)			PAGE 5 OF 6
CONFIGURATION	DELTA ORBITER	BY		DATE 15 June 1971

14. ENVIRONMENTAL CONTROL								7849
GAS SUPPLY SYSTEM (DRY)								
GAS MANAGEMENT, PROCESSING (DRY)								
HEAT TRANSPORT SYSTEM (DRY)								
WATER MANAGEMENT SYSTEM (DRY)								
15. PERSONNEL PROVISIONS								430
SEATS 'RESTRAINT SYS (NO =)								
FIXED LIFE SUPPORT EQUIPMENT								
EMERGENCY EQUIPMENT								
CARGO HANDLING								
FURNISHINGS								
16. RANGE SAFETY AND ABORT								0
17. BALLAST								0
18. GROWTH/UNCERTAINTY								23086
19. OPEN								
SUBTOTAL (DRY WEIGHT)								(221866)
20. PERSONNEL	NO	MAN	GARMENTS	HELMET	PRESS. SUIT	ACCESSORIES		626
CREW	( )							
PASSENGER	( )							
PERSONEL GEAR/ACCESSORIES								
LIFE SUPPORT								
FOOD								
EQUIPMENT – PORTABLE								
21. CARGO								40000
22. ORDNANCE								0
23. RESIDUAL & UNUSABLE FLUIDS								4001
ASCENT							737	
CRUISE							0	
MANEUVER							1430	
ATTITUDE CONTROL							Incl Maneu	
ECS							621	
EPS							0	
HYDRAULIC							1087	
MISC. (SHOCK STRUT, ETC.)							126	
24. OPEN								
SUBTOTAL (INERT WEIGHT)								(266493)

TABLE B.3-4 GROUP WEIGHT STATEMENT (POLAR) — PAGE 6 OF 6

CONFIGURATION	DELTA ORBITER	BY		DATE	15 June 1971

25. RESERVE FLUIDS				16178
ASCENT			6184	
CRUISE			0	
MANEUVER			8082	
ATTITUDE CONTROL			1662	
ECS			102	
EPS			0	
HYDRAULIC			148	
26. INFLIGHT LOSSES				9788
ASCENT			6467	
CRUISE			0	
MANEUVER			1552	
ATTITUDE CONTROL			Incl Maneu	
ECS			324	
EPS			640	
HYDRAULIC			805	
27. PROPELLANT - ASCENT	MAIN	AUXILIARY		548927
	526559	22368		
28. PROPELLANT - CRUISE				0
	MANEUV.	ACS		
29. PROPELLANT - MANEUV ACS	10359	1663		12022
TOTAL (GROSS WEIGHT)				(853408)

TABLE B.3-5

DESIGN DATA (DELTA ORBITER,
40K POLAR MISSION)

Pages 1 thru 7 are the same as shown for the Easterly Mission in Section 4. Page 8 follows.

TABLE B.3-5 DESIGN DATA SUMMARY (POLAR) PAGE 8 OF 8

CONFIGURATION: DELTA ORBITER | BY: | DATE: 15 June 1971

27 - 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO (BY WEIGHT)	6	N/A	5 & 3.53	5 & 3.53
OXIDIZER ULLAGE VOLUME - PERCENT*	5.5**		49.9	49.9
FUEL ULLAGE VOLUME - PERCENT*	5.5**		43.5	43.5
FUEL DENSITY - PCF	4.395		4.37	4.37
OXIDIZER DENSITY - PCF	71.0		70.6	70.6
FUEL BIAS - PERCENT	.25			
INCREMENTAL VELOCITY - FPS	(15542		715	N/A
INERTIAL	14905)			
ANGLE OF ATTACK	82			
GRAVITY LOSSES	220			
DRAG LOSSES	2			
BACK PRESSURE LOSSES	29			
FLT. PERFORMANCE RESERVE	304			
RANGE - NA MI		(_____)		
GROUND MILES		_____		
HEAD WIND ALLOW.		_____		
CONTINGENCY		_____		
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING GO-AROUND-MINUTES		_____		

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES.

** 3% PLUS 1% LOAD ALLOWANCE FOR MIN I_{SP} LOADING

TABLE B.3-6 SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
40K POLAR MISSION
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	31587.	1738.	0.	194.	540.	423.	962.
					0.	0.	4.
TAILS	5104.	2054.	0.	632.	2.	11.	11.
					0.	0.	2.
BODY	55500.	1292.	0.	291.	191.	2605.	2551.
					0.	0.	82.
THERMAL PROT	32847.	1353.	-0.	191.	388.	2734.	3035.
					-0.	-0.	-6.
LANDING/DOCK	10551.	1438.	-0.	129.	102.	432.	452.
					-0.	-0.	-36.
PROP-ASCENT	26637.	1863.	4.	320.	42.	416.	395.
					-3.	-1.	3.
PROP-CRUISE	574.	1542.	25.	288.	3.	2.	4.
					0.	-0.	-0.
PROP-AUXIL	11877.	1291.	6.	320.	31.	677.	691.
					-0.	1.	-28.
PRIME POWER	2272.	1015.	-31.	258.	1.	264.	265.
					-12.	-0.	9.
ELEC DIST	1303.	832.	-16.	235.	0.	48.	48.
					-2.	-0.	2.
HYDRA DIST	2760.	1705.	-52.	262.	5.	42.	45.
					-2.	-0.	3.
SURF CONTROL	4001.	1944.	0.	308.	92.	33.	71.
					0.	0.	7.
AVIONICS	4588.	1030.	1.	384.	12.	101.	99.
					1.	-0.	-5.
ENVIR CONTRL	7849.	1124.	0.	363.	0.	99.	74.
					0.	0.	0.
PERSNL PROV	430.	962.	7.	451.	0.	0.	0.
					-0.	-0.	-0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	23036.	1479.	0.	269.	0.	0.	0.
					0.	0.	0.
DRY WEIGHT	221865.	1479.	-0.	269.	1753.	11431.	11985.
					-11.	2.	167.
PERSONNEL	626.	951.	-1.	455.	0.	0.	0.
					-0.	-0.	-0.
LANDED CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
RESID FLUIDS	4001.	1385.	0.	279.	20.	252.	238.
					0.	-0.	-20.

TABLE B.3-6 (Cont.)

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
40K POLAR MISSION
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
		(INCH)			PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
INERT WEIGHT	266492.	1468.	-0.	290.	1038.	12291.	12703.
					-11.	2.	80.
RESERVE FLDS	10013.	1789.	0.	280.	17.	253.	266.
					0.	-0.	-24.
LANDING WT	276505.	1479.	-0.	289.	1055.	12759.	13183.
					-11.	2.	49.
CRUISE PROP	37.	17869.	0.	23401.	-4332.	-6389.	-2056.
					0.	0.	-3039.
FLIGHT WT	276542.	1482.	-0.	292.	1888.	12780.	13272.
					-11.	2.	35.
ENTRY ACS	1834.	1477.	-0.	307.	3.	105.	106.
					-0.	0.	-9.
ENTRY WT	278376.	1482.	-0.	292.	1891.	12886.	13379.
					-11.	2.	25.
RETRO PROP	4901.	1741.	0.	283.	8.	162.	167.
					0.	0.	-14.
PRE RETRO WT	283277.	1486.	-0.	292.	1900.	13118.	13616.
					-11.	2.	9.
ON ORB LOSS	6735.	1506.	0.	303.	10.	381.	385.
					0.	-0.	-33.
LANDED CARGO	-40000.	1420.	0.	400.	-35.	-410.	-410.
					0.	0.	0.
ASCENT CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
ON ORBIT WT	290012.	1487.	-0.	292.	1910.	13500.	14002.
					-11.	2.	-23.
MANEUV PROP	1765.	1741.	-0.	283.	3.	58.	60.
					-0.	0.	-5.
DUMPED PROP	10298.	812.	0.	228.	5.	81.	85.
					0.	0.	0.
INJECTION WT	302075.	1465.	-0.	290.	1926.	14653.	15153.
					-11.	2.	64.

TABLE B.3-6(CONT.)

SEQUENCED MASS PROPERTIES SUMMARY 06/14/71
40K POLAR MISSION
(DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ASCENT PROP	144181.	1054.	0.	233.	132.	3587.	3693.
					0.	-0.	55.
75% BURN	446256.	1332.	-0.	272.	2127.	21862.	22330.
					-12.	2.	613.
ASCENT PROP	135151.	910.	0.	229.	97.	2052.	2142.
					0.	0.	24.
50% BURN	581407.	1234.	-0.	262.	2263.	27955.	28542.
					-13.	1.	1038.
ASCENT PROP	135019.	787.	0.	229.	72.	1827.	1893.
					0.	0.	29.
25% BURN	716426.	1150.	-0.	256.	2360.	34528.	35155.
					-14.	1.	1411.
ASCENT PROP	135019.	621.	0.	229.	91.	1943.	2027.
					0.	0.	35.
IGNITION	851445.	1066.	-0.	252.	2469.	43347.	44042.
					-14.	1.	1789.
STARTUP	1962.	861.	0.	228.	1.	24.	25.
					0.	0.	0.
LAUNCH WT	853407.	1066.	-0.	252.	2470.	43388.	44084.
					-14.	1.	1791.

TABLE B.3-7 MISSION WEIGHT SUMMARY (POLAR MISSION)

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	57954							
2	TAIL GROUP	19214							
3	BODY GROUP	148599							
4	INDUCED ENVIR PROTECTION	84807							
5	LANDING, RECOVERY, DOCKING	25885							
6	PROPULSION-ASCENT	123320							
7	PROPULSION-CRUISE	37053							
8	PROPULSION-AUXILIARY	5396							
9	PRIME POWER	3582							
10	ELECT CONVER & DISTR	1818							
11	HYDRA CONVER & DISTR	7282							
12	SURFACE CONTROLS	11320							
13	AVIONICS	4941							
14	ENVIRONMENTAL CONTROL	2058							
15	PERSONNEL PROVISIONS	288							
16	RANGE SAFETY & ABORT								
17	BALLAST								
18	GROWTH UNCERTAINTY	42483							
19									
	SUBTOTAL DRY WEIGHT	(576000)							
20	PERSONNEL	522							
21	CARGO								
22	ORDNANCE								
23	RESIDUAL FLUIDS	14127							
24									
	SUBTOTAL INERT WEIGHT	(590649)							
25	RESERVE FLUIDS	11245	11245	11245	11245	11245	245		
26	IN FLIGHT LOSSES	22847	22847	22847	2035				
27	PROPELLANT-ASCENT	3038600	1519300						
28	PROPELLANT-CRUISE	91000	97000	97000	97000	10000	10000		
29	PROPELLANT-MANEUV ACS	1212	1212	1212					
30									
	TOTAL GROSS-WEIGHT LB	3755553	2242253	722953	700929	611894	600894		

DESIGNATORS:

EVENTS
A LAUNCH WEIGHT
B 50% BURN
C BURNOUT
D START CRUISE
E END CRUISE
F LANDING
G
H

NOTES & SKETCHES:

(POLAR)

TABLE B.3-8 GROUP WEIGHT STATEMENT — PAGE 1 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

1. WING GROUP		CARRY THROUGH ( )	EXPOSED SURFACE ( )	57954
BASIC STRUCTURE				
TORQUE BOX				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
VARIABLE GEOMETRY (INCL ____ LBS MECHANISM)				
DOORS, INSULATION, FAIRINGS				
CONTROL SURFACES		SURFACE	SUPT/MECH	
AILERONS – (INCL. BAL WT_____LB)				
T.E. FLAPS				
L.E. FLAPS				
SPOILERS				
SPEED BRAKES				
2. TAIL GROUP		VERTICAL ( )	HORIZ ( )	19214
BASIC STRUCTURE				
TORQUE BOX				
CARRY THROUGH				
LEADING EDGE				
TRAILING EDGE				
SECONDARY STRUCTURE				
CONTROL SURFACES		SURFACE	SUPT MECH	
RUDDER (INCL. BAL WT_____LB)				
ELEVATOR (INCL. BAL WT_____LB)				
3. BODY GROUP				148599
INTEGRAL TANKAGE				
FUEL TANK				
OXIDIZER TANK				
BETWEEN TANKS (CMN BLKHD)				
INSULATION				
BASIC STRUCTURE	FWD. ( )	CTR, ( )	AFT, ( )	SKIRT ( )
SIDEWALLS				
BULKHEADS				
PARTITIONS				
THRUST STRUCTURE (MAIN ASCENT ENGINE)				
SECONDARY STRUCTURE				
CREW COMPARTMENT				
EQUIPMENT COMPARTMENTS				
RADOME ANTENNAS				
SPEED BRAKES				
ENGINE HEAT PROTECTION				
INTERSTAGE (INCL. MECH._____LBS)				
DOORS FAIRINGS				
GEAR WING PROVISIONS				
CONTINGENCY				

NOTE: SUBSYSTEM DETAILS ARE LISTED ONLY WHERE SUBSYSTEM TOTAL IS DIFFERENT THAN FOR EASTERLY MISSION.

(POLAR)

TABLE B.3-8	GROUP WEIGHT STATEMENT			PAGE 2 OF 6	
CONFIGURATION	CANARD BOOSTER	BY		DATE	15 June 1971

24807

4. INDUCED ENVIRONMENT PROTECTION

	WING	HOR. TAIL	VER. TAIL	BODY	( )
THERMAL PROTECTION					
LEADING EDGE 'NOSE CAP*	( )	( )	( )	( )	
SURFACE PROTECTION*	( )	( )	( )	( )	
BASE HEAT PROTECTION*				( )	
SOUND PROTECTION					( )
METEORITE 'RADIATION PROTECTION					( )

*BREAK OUT BY TYPE OF MATERIAL

(POLAR)

TABLE B.3-8 GROUP WEIGHT STATEMENT — PAGE 3 OF 6

CONFIGURATION: CANARD BOOSTER — BY: — DATE: 15 June 1971

5. LANDING, DOCKING		ROLLING	STRUC-TURE	CON-TROLS		25885
ALIGHTING GEAR						
MAIN						
NOSE						
DOCKING						
AUXILIARY SYSTEMS						
DECELERATION CHUTES						
FLOTATION GEAR						
HANDLING GEAR						
CONTINGENCY						123320
6. PROPULSION – MAIN ASCENT						
ENGINE & ACCESSORIES						
ENGINE (AS SUPPLIED)						
GIMBAL SYSTEM						
IGNITION AND CONTROL SYSTEM						
PROPELLANT UTILIZATION SY						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUDS						
PROPELLANT SY			FUEL	OXIDIZER		
FILL DRAIN						
PRESSURIZATION						
VENT SY						
PCV SY						
PRE-VALVES						
FEED SYSTEMS						
VORTEX, FLOW CONTROL SYSTEM						
SUPPORTS AND INSTALL						
TANKAGE – NONINTEGRAL	TANK	INSULATE	SUPTS			
FUEL						
OXIDIZER						37053
CONTINGENCY						
7. PROPULSION – CRUISE BACK						
ENGINE & ACCESSORIES						
ENGINE						
IGNITION AND CONTROL SY						
LUBRICATION SY (DRY)						
ACCESSORIES						
INSTALLATION, DUCTS, SHROUD						
AIR INDUCTION						
ENGINE MOUNTING						
NACELLES PYLONS INCL ____ LB MECH)						
EXHAUST SY						
PROPELLANT SY						
FILL DRAIN						
PRESSURIZATION (DRY)						
VENT SY						
PUMP						
FEED SY						
TRANSFER SY						
DUMP SY						
SUPPORTS INSTALLATION						
TANKAGE – NON INTEGRAL	TANK	INSULATE	SUPTS			
FUEL						
CONTINGENCY						

(POLAR)

TABLE B.3-8 GROUP WEIGHT STATEMENT — PAGE 4 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

8. PROPULSION – AUXILIARY			ATT. CONTROL		MANEU-VER		5396
THRUSTER INSTALLATION							
THRUSTER							
ACCESSORY							
PROPELLANT SY							
FILL 'DRAIN							
PRESSURIZATION							
VENT							
FEED SYSTEM							
DUMP SYSTEM							
SUPPORTS							
TANKAGE							
TANKS							
INSULATION							
SUPPORTS							
CONTINGENCY							

9. PRIME POWER	POWER UNIT	MTG INSTAL	PROPEL TANK/SYS	TEMP CONTROL	CON-TROLS	TOTAL	3582
BATTERIES						( )	
ENGINE TURBINE						( )	
FUEL CELL						( )	

10. ELECTRICAL	SUPPLY	CONVER-SION	CONTROL UNITS			1818
EQUIPMENT						
DISTRIBUTION AND CONTROL CIRCUITRY						
UTILITY SYSTEMS						
SUPPORTS/INSTALLATION						

11. HYDRAULIC	PRIMARY ( )	UTILITY ( )	EMERG ( )			7282
POWER SUPPLY						
DISTRIBUTION CONTROL CTR						
TEMPERATURE CONTROL SY						
AUXILIARY SYSTEMS						
SUPPORTS INSTALLATION						

12. SURFACE CONTROLS							11320
COCKPIT CONTROLS							
FLIGHT CONTROL SY							
SYSTEM ACTUATION	CONTROLS ( )	POWER XMISSION ( )	ACTUATOR ( )	FEEL SY ( )	SUPTS INSTALL. ( )	(SEE AVIONICS)	
AILERON							
ELEVATOR							
RUDDER							
T.E. FLAP							
SPEED BRAKE							

13. AVIONICS	UNITS ( )	CIRCUITRY ( )	COOLING ( )	ANTENNAS ( )	INSTALL. ( )		4941
GUID NAV							
FLIGHT CONTROL							
DATA MANAGEMENT							
COMMUNICATE							
CONFIG. SEQ,							
INSTRUMENTATION							
DISPLAYS							
CONTINGENCY							

(POLAR)

TABLE B.3-8 GROUP WEIGHT STATEMENT — PAGE 5 OF 6

CONFIGURATION: CANARD BOOSTER | BY: | DATE: 15 June 1971

14. ENVIRONMENTAL CONTROL							2058
GAS SUPPLY SYSTEM (DRY)							
GAS MANAGEMENT, PROCESSING (DRY)							
HEAT TRANSPORT SYSTEM (DRY)							
WATER MANAGEMENT SYSTEM (DRY)							
15. PERSONNEL PROVISIONS							288
SEATS 'RESTRAINT SYS (NO =)							
FIXED LIFE SUPPORT EQUIPMENT							
EMERGENCY EQUIPMENT							
CARGO HANDLING							
FURNISHINGS							
16. RANGE SAFETY AND ABORT							0
17. BALLAST							0
18. GROWTH/UNCERTAINTY							42483
19. OPEN							
SUBTOTAL (DRY WEIGHT)							(576000)
20. PERSONNEL	NO	MAN	GARMENTS	HELMET	PRESS. SUIT	ACCESSORIES	522
CREW	( )						
PASSENGER	( )						
PERSONEL GEAR 'ACCESSORIES							
LIFE SUPPORT							
FOOD							
EQUIPMENT – PORTABLE							
21. CARGO							0 0
22. ORDNANCE							
23. RESIDUAL & UNUSABLE FLUIDS							14127
ASCENT							4796
CRUISE							3465
MANEUVER							0
ATTITUDE CONTROL							306
ECS							84
APU							55
HYDRAULIC							5381
MISCELLANEOUS							40
24. OPEN							0
SUBTOTAL (INERT WEIGHT)							(590649)

(POLAR)

TABLE B.3-8 GROUP WEIGHT STATEMENT				PAGE 6 OF 6	
CONFIGURATION	CANARD BOOSTER	BY		DATE	15 June 1971
					11245
25. RESERVE FLUIDS					
ASCENT				0	
CRUISE				11000	
MANEUVER				0	
ATTITUDE CONTROL				54	
ECS				0	
APU				191	
HYDRAULIC				0	
					22847
26. INFLIGHT LOSSES					
ASCENT					
CRUISE					
MANEUVER					
ATTITUDE CONTROL					
ECS					
EPS					
HYDRAULIC					
					3038600
27. PROPELLANT – ASCENT					
					91000
28. PROPELLANT – CRUISE					
			MANEUV.	ACS	
					1212
29. PROPELLANT – MANEUV ACS					
					(3755553)
TOTAL (GROSS WEIGHT)					

TABLE B.3-9

DESIGN DATA SUMMARY (CANARD BOOSTER,

POLAR MISSION)

Pages 1 thru 7 of Design Data Summary are same as for Easterly Mission except:

- Growth/uncertainty which changes from 42009 to 42483 lb
- Cruise range which changes from 450 to 439 nm.

The ΔV's on page 8 are revised as shown on the following page.

TABLE B.3-9 DESIGN DATA SUMMARY				PAGE 8 OF 8	
CONFIGURATION	CANARD BOOSTER	BY		DATE	15 June 1971

(40K POLAR)

27 – 29 PROPELLANTS EXPENDED

	ASCENT	CRUISE	MANEUVER	ATTITUDE
OXIDIZER FUEL RATIO (BY WEIGHT)				
OXIDIZER ULLAGE VOLUME – PERCENT*				
FUEL ULLAGE VOLUME – PERCENT*				
FUEL DENSITY – PCF				
OXIDIZER DENSITY – PCF				
FUEL BIAS – PERCENT				
INCREMENTAL VELOCITY – FPS	(15201)			
INERTIAL	11026			
ANGLE OF ATTACK	39			
GRAVITY LOSSES	3363			
DRAG LOSSES	505			
BACK PRESSURE LOSSES	268			
FLT. PERFORMANCE RESERVE				
RANGE – NA MI		(510)		
GROUND MILES		442		
HEAD WIND /ENGINE OUT ALLOW		68		
CONTINGENCY				
EQUIVALENT BURN TIME AT FULL THRUST PROVIDED FOR LANDING GO-AROUND–MINUTES		5.1		

* BASED ON NOMINAL LOADING (INCLUDE EXTRA TANK VOLUME PROVIDED FOR OFF-NOMINAL MISSIONS AS ULLAGE BUT DO NOT INCLUDE VOLUME OF NORMAL RESERVES, RESIDUALS, OR IN FLIGHT LOSSES.

TABLE B.3-10 SEQUENCED MASS PROPERTIES SUMMARY 06/16/71
CANARD BOOSTER POLAR MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
		(INCH)			PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	57054.	3707.	0.	500.	2038.	244.	2800.
					0.	0.	16.
TAIL&CANARD	10214.	3278.	0.	475.	2466.	4680.	6714.
					0.	0.	880.
BODY	148500.	2816.	0.	395.	985.	20740.	20710.
					0.	0.	-100.
THERMAL PROT	84807.	3053.	0.	441.	3071.	14592.	16806.
					0.	0.	1124.
LANDING GEAR	25885.	3008.	0.	286.	153.	3035.	2960.
					0.	0.	-28.
ASCENT PROP	123320.	3708.	0.	430.	274.	4706.	4767.
					5.	0.	-235.
CRUISE PROP	37053.	2111.	0.	240.	235.	1106.	1302.
					1.	0.	203.
ORIENT SYS	5396.	2331.	14.	546.	8.	447.	453.
					-5.	0.	-1.
SURF CONTROL	11320.	3851.	0.	618.	883.	465.	1271.
					0.	0.	109.
PRIME POWER	3582.	3654.	0.	281.	1.	22.	22.
					0.	0.	0.
ELEC CON/DIS	1818.	2299.	0.	507.	2.	35.	34.
					0.	0.	4.
HYDRAULICS	7282.	3700.	0.	400.	4.	16.	16.
					0.	0.	0.
AVIONICS	4941.	1838.	0.	429.	5.	938.	937.
					0.	0.	0.
LAUNCH ESC	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
ECLS	2058.	2352.	0.	435.	6.	482.	477.
					0.	0.	14.
PERS PROV	288.	1120.	0.	423.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
PEND CHNGS	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH	42483.	3095.	0.	420.	92.	3301.	3301.
					0.	0.	0.
DRY WT	576000.	3163.	0.	426.	11726.	87211.	93887.
					-14.	2.	5388.
PERSONNEL	522.	1110.	0.	425.	0.	0.	0.
					0.	0.	0.
RESIDUALS	14127.	2871.	2.	422.	129.	2884.	2943.
					-5.	1.	46.

TABLE B.3-10 (Cont.)

SEQUENCED MASS PROPERTIES SUMMARY 06/16/71
CANARD BOOSTER POLAR MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
RESERVE	10245.	3801.	0.	599.	540.	172.	711.
					-1.	-0.	6.
LANDING WT	600894.	3166.	0.	429.	12460.	91967.	99178.
					-21.	3.	5686.
CRU RESR DMP	11000.	3845.	0.	600.	0.	0.	0.
					0.	0.	0.
END OF CRUSE	611894.	3178.	0.	432.	12528.	93112.	100254.
					-22.	3.	5058.
CRU PRO USED	31000.	2275.	0.	402.	714.	7018.	7512.
					0.	0.	872.
APU PROP	2035.	2023.	6.	540.	0.	-0.	0.
					0.	0.	0.
CRUISE START	604029.	3069.	0.	429.	13262.	113228.	120845.
					-22.	3.	7200.
INFLT LOSS	20812.	3313.	1.	402.	1.	2214.	2213.
					-4.	0.	-11.
ORIENT PROP	1212.	2023.	82.	400.	0.	0.	0.
					0.	0.	0.
PEND CHNGS	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BURN OUT WT	716953.	3074.	0.	428.	13260.	115995.	123609.
					-47.	3.	7169.
ASCENT PROP	759650.	2111.	0.	400.	0.	49800.	49800.
					0.	0.	0.
75% BURN	1476603.	2579.	0.	414.	13331.	239740.	247292.
					-22.	4.	9312.
ASCENT PROP	759650.	1938.	0.	400.	0.	36507.	36507.
					0.	0.	0.
50% BURN	2236253.	2361.	0.	409.	13351.	320776.	328308.
					-11.	4.	10254.
ASCENT PROP	759650.	1764.	0.	400.	0.	23195.	23195.
					0.	0.	0.

TABLE B.3-10 (Cont.)
SEQUENCED MASS PROPERTIES SUMMARY 06/16/71
CANARD BOOSTER POLAR MISSION

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
25% BURN	2095003.	2210.	0.	407.	13361.	387576.	395008.
					-3.	4.	10000.
ASCENT PROP	759650.	1605.	0.	400.	-0.	17496.	17496.
					0.	0.	0.
LAUNCH WT	3755553.	2087.	0.	405.	13367.	452083.	469500.
					4.	4.	11438.

Appendix C

Comparison of Phase B Shuttle Weights to Historical Data

C.1 Summary - The Phase B Space Shuttle detailed weight calculations and substantiating data are presented in Parts II and III of this report. In this appendix, these weights are compared to previous aircraft and spacecraft. Gross body, wing, tail and landing gear comparisons are presented in Section C.2. More detailed comparisons for certain subsystems and subsystem elements are presented in Section C.3. In Section C.4 weight and design data summaries are shown for selected vehicles. In these summaries the weights have been regrouped to the standard shuttle format to permit more direct comparisons to the corresponding shuttle orbiter and booster weights.

C.2 Gross Comparisons - Our current Phase B weights are based on indepth analyses of our Phase B point design. The resulting body group, wing, tail and landing gear weights appear quite realistic when compared to similar weight groupings for previous aircraft and spacecraft. No similar comparisons for thermal protection and propulsion systems have been presented because state of the art advances in these areas have been so significant that comparisons to past designs e.g. Apollo or Gemini heatshield, Saturn propulsion systems, etc., are not meaningfull.

In Figure C.2-1 body group weight is plotted versus body (fuselage) wetted area. This wetted area includes base and/or end areas. A trend line through the data shows an average unit weight of 4.67 lbs/sq.ft. The orbiter plots very near this line and the booster well above it. The "piggy back" orbiter, however, introduces significant loads into the booster which were not present in the past designs and the heavier booster weight is probably justified.

Wing group weight is plotted versus wing gross area in Figure C.2-2. The wing gross (or theoretical) area was obtained by extending the leading and trailing edges until they intersect and calculating total chord plane projected area

FIGURE C.2-1

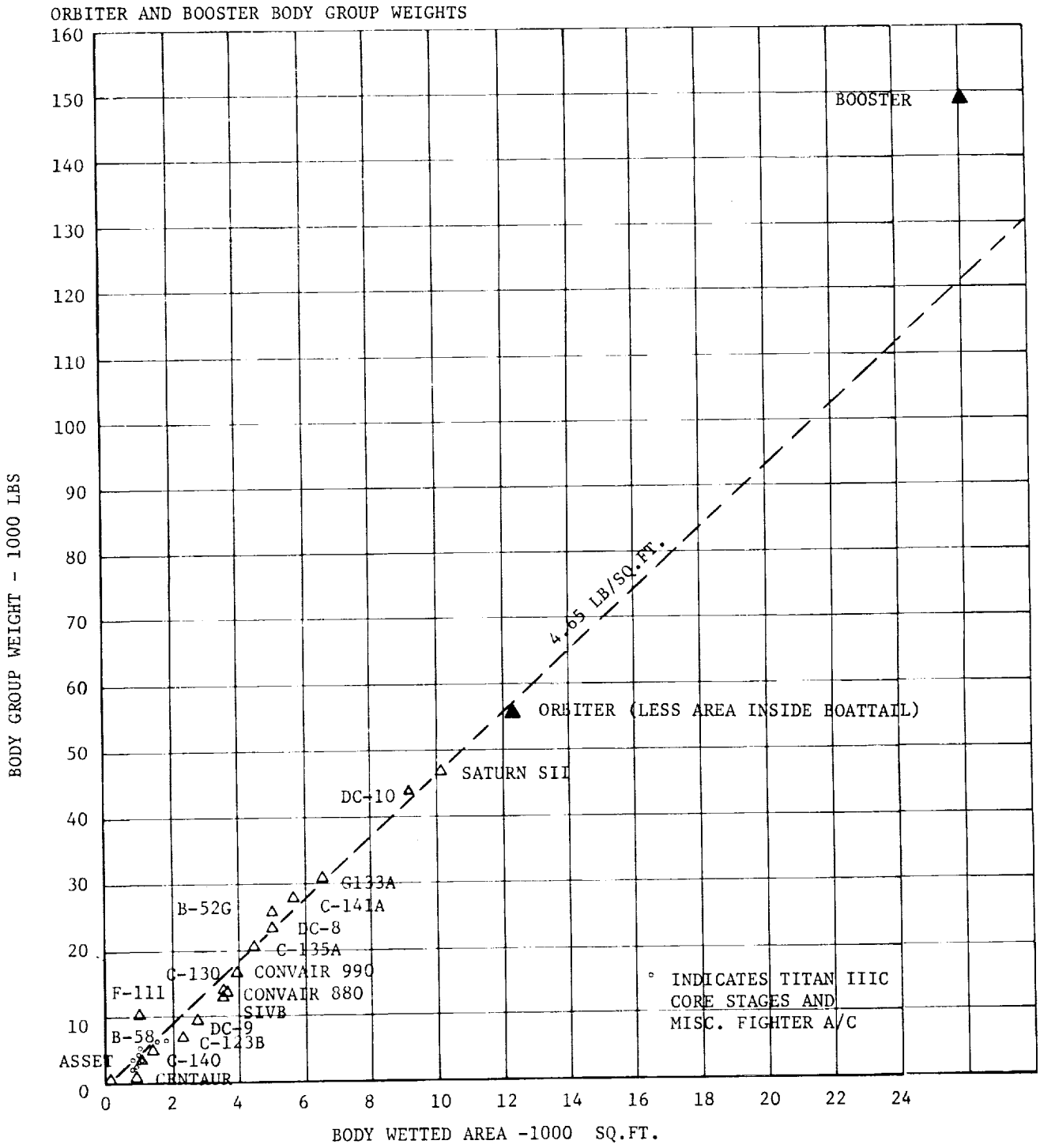
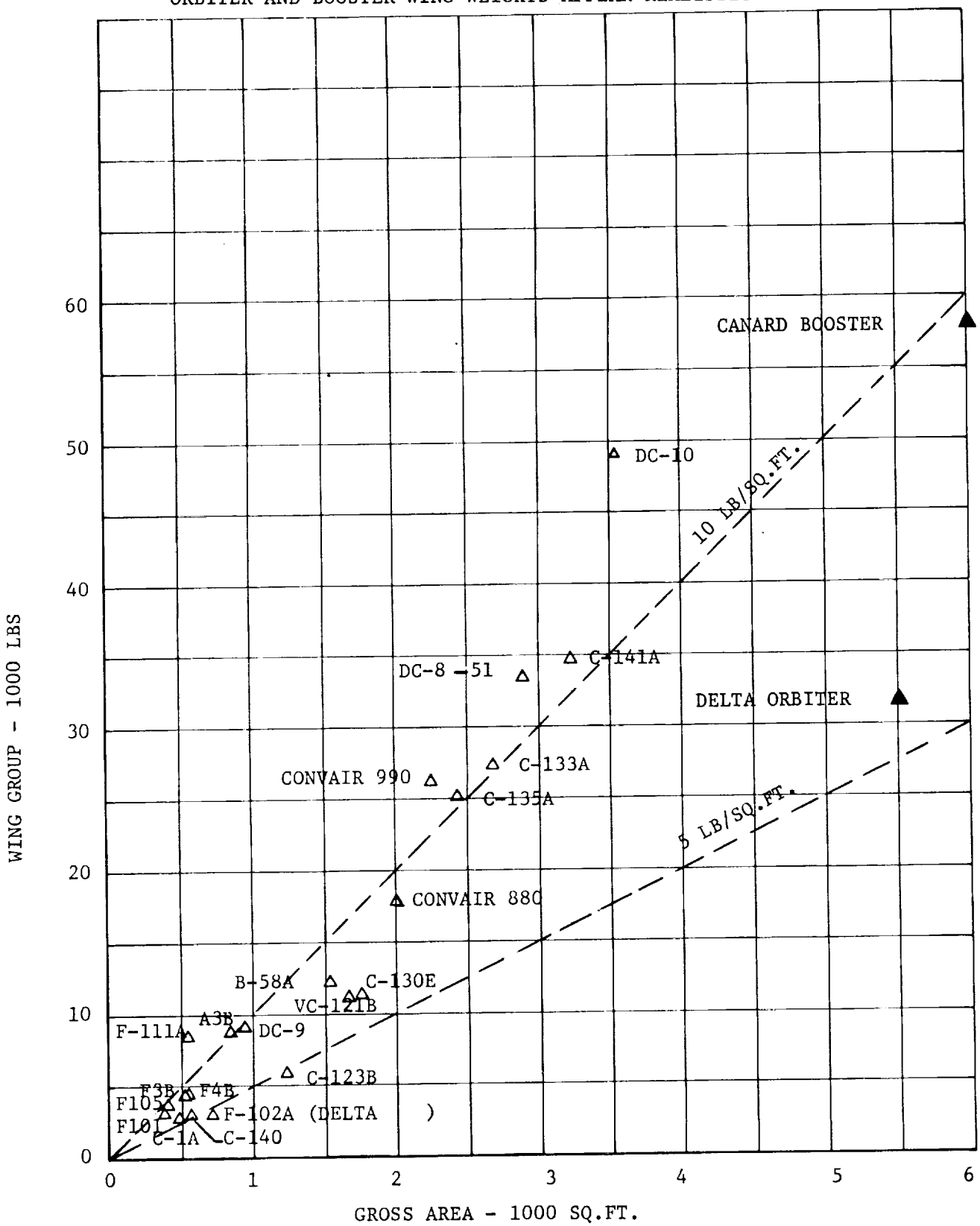

ORBITER AND BOOSTER BODY GROUP WEIGHTS
BODY GROUP WEIGHT - 1000 LBS
BODY WETTED AREA -1000 SQ.FT.
BOOSTER
4.65 LB/SQ.FT.
ORBITER (LESS AREA INSIDE BOATTAIL)
SATURN SII
DC-10
G133A
C-141A
B-52G
DC-8
C-135A
C-130
CONVAIR 990
F-111
CONVAIR 880
SIVB
DC-9
B-58
C-123B
C-140
CENTAUR
° INDICATES TITAN IIIC CORE STAGES AND MISC. FIGHTER A/C

FIGURE C.2-2

ORBITER AND BOOSTER WING WEIGHTS APPEAR REALISTIC



including that submerged in the fuselage. The data shows quite a bit of scatter which is not unexpected. The samples shown include wings with significantly different aspect ratios, loads, sweep angles and planform and thickness taper ratios, all of which effect the resultant wing weights. A trend line of 10 lb/sq.ft. appears reasonable for most of the data. The booster falls just below this line. The orbiter falls well below the 10 lb/sq.ft. line but it is a very low aspect ratio delta wing and a trend line of around 5 lb/sq.ft. is considered reasonable for a wing of this type. More detailed comparisons of the wing torque boxes and control surfaces to past hardware is included in Section C.3.

The tail weights shown in Figure C.2-3 show scatter for the same reasons as the wing data. Unless otherwise indicated, total tail area and total tail weight have been used instead of plotting horizontal and vertical tails separately. A trend line through the data shows an average unit weight of 5.5 lb/sq.ft. The orbiter and booster tail weights each plot well above this line and therefore appear realistic or even somewhat conservative.

Figure C.2-4 shows a suprisingly "tight" correlation of gear weights which was obtained using only takeoff gross weight as the normalizing parameter. The Orbiter and the Booster gear both plot below the trend line. This is not only considered realistic but necessary for an accurate weight evaluation of gears which have the following design and design requirement variations.

Design/Design Requirements	Shuttle	Typical Gear on C.2-4	Comment
o Runway Thickness (Flotation)	20 in.	12 in.	This increases flotation allowables which reduces the tire, wheel and bogey beam weights.
o Design Weight	Landing	Takeoff	The ferry takeoff weight is a design overload condition wherever possible.
o Brake Life	6 Landings	100 Landings	Reduces brake weight
o Brake Material	Carbon	Steel	Considerable reduction in brake weight (30%)

FIGURE C.2-3

ORBITER AND BOOSTER TAIL WEIGHTS APPEAR REALISTIC

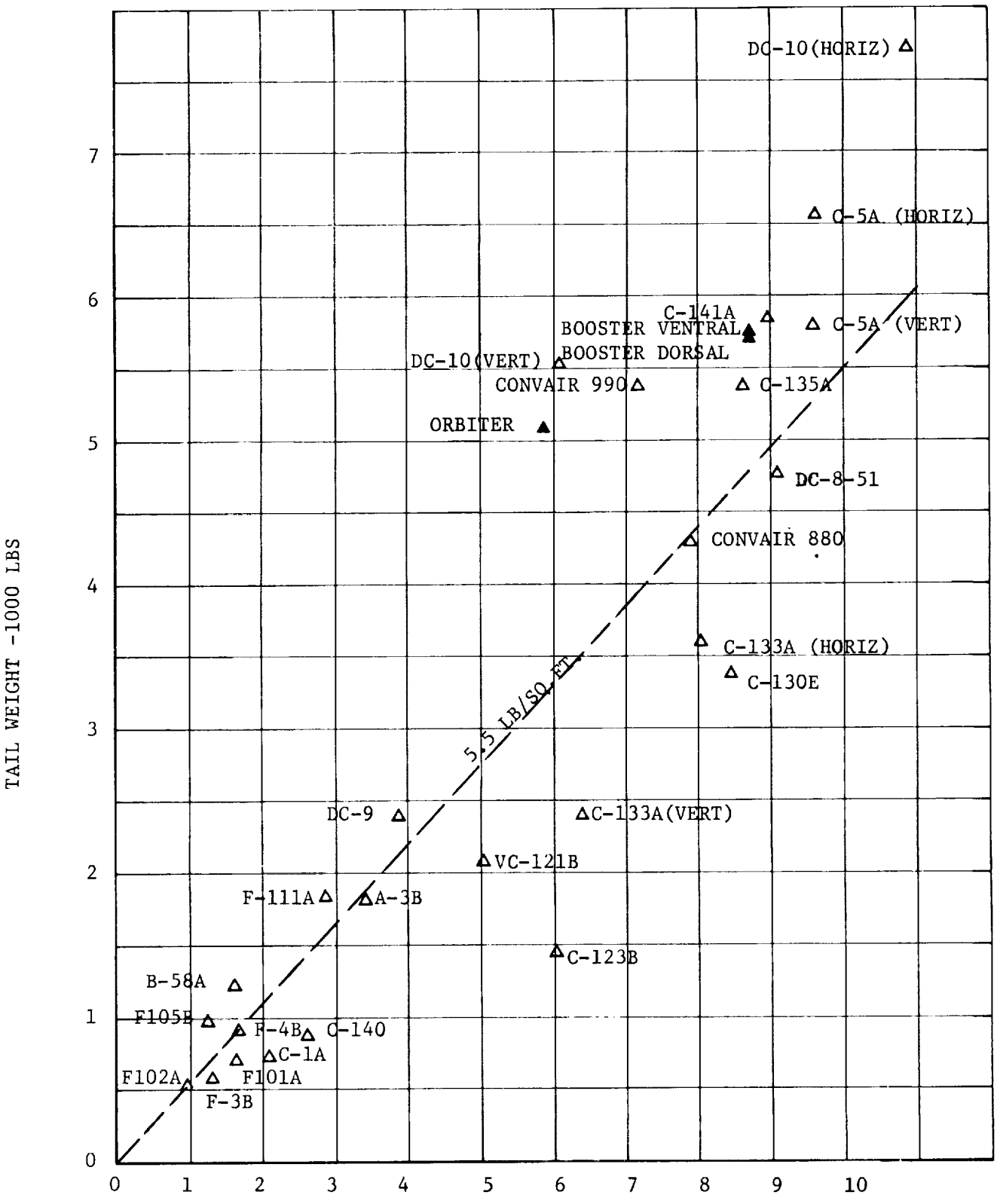


FIGURE C.2-4

ORBITER AND BOOSTER GEAR WEIGHTS APPEAR REALISTIC

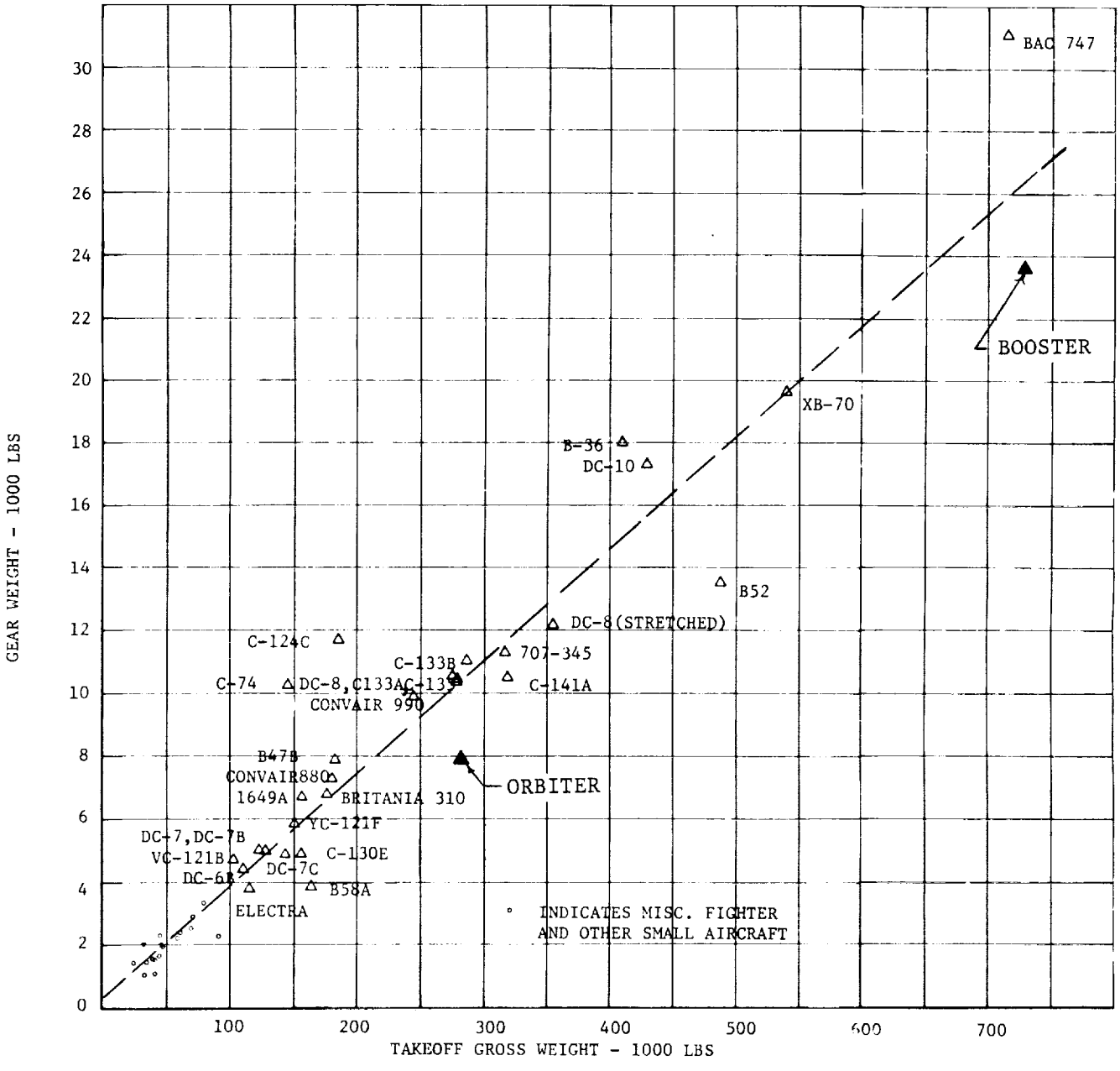


TABLE C.2-1

LANDING GEAR WEIGHTS

VEHICLE	GEAR WEIGHT LBS	TAKEOFF GROSS WEIGHT - LBS
DC-35	2019	31000
DC-6B	4401	107100
DC-7	5035	122200
DC-7B	5025	126000
DC-7C	4886	143000
Britania 310	6820	175000
Martin 404	2330	45000
C-74	10305	145000
YC 121F	5853	150000
C-124C	11700	185000
Convair 240	1537	39500
Convair 340	2073	45000
Viscount 800	2567	67500
Viscount 700	2263	58500
Electra	3845	113000
1649A	6701	156000
C133B	10059	286000
707-345	11309	316000
A-3B	2914	69800
F-3B	1459	32000
F-4B	1732	43600
F-101A	1552	39900
F-102A	1056	31300
F-105B	1995	47600
F-111A	2296	90450
C-1A	1396	24800
VC-121B	4771	102200
C-123B	2372	60200
C-130E	4939	155000
C-133A	10635	275000
C-135A	10444	279500
C-140	1081	40300
C-141A	10515	318000
Convair 880	7344	180600
Convair 990	9946	245000
DC8-51	10587	278000
DC-9	3376	77800
B58A	3856	163000
C5A	37580	769000
DC-10	17308	430000
XB-70	19661	542000
BAC747	31108	713000
B52	13522	488000
B36	18057	410000
DC-8(Stretched)	12185	355000
B47B	7986	181000
Orbiter	7980	282000
Booster	23600	722000

It is also noted that the B52 and B58A, which were designed to Shuttle flotation requirements, falls slightly below a line defined by the Orbiter and Booster data points. This, without even considering the anticipated weight reduction resulting from brake material and life differences, shows that the Shuttle gear weights are high.

C.3 Detailed Correlations - The correlations in this section show that major elements of the vehicle weight, which were derived based on detailed Phase B design analyses, also appear realistic when compared to past hardware design. Correlations are shown for:

- o Wing Group
- o Tail Group
- o Integral Tankage
- o Thrust Structure

The Wing and Tail group correlations are based on an MDAC Aerosurface Weight Prediction method which is described in section C.3.5.

In any cases where weight correlations to past hardware have been used as the basis for final detailed weights, these correlations are presented in the weight substantiation sections of Parts II and III of this report.

C.3.1 Wing Group - Throughout the Phase B activity we have used the MDAC aerosurface program for preliminary wing weight estimates and as a method of scaling wing weights for vehicle sizing/synthesis analyses and trade studies. Estimation wing weights from the Aerosurface program (AEROSURF) for the Delta Orbiter and Canard Booster are compared to weights obtained by detailed analysis in Table C.3-1. This comparison shows that the aerosurface program matches the calculated Delta Orbiter wing weight within 2.5 percent and the Canard Booster wing within 2.8 percent. These close correlations lend credence both to the calculated wing weights and to our use of the aerosurface program in support of trade studies and other parametric work.

Substantiation for the detailed analysis weights shown in Table C.3-1 is presented in Parts II and III of this report.

Table C.3-1

Comparison of Wing Weights from Detailed Analysis to Those from Aerosurface Weight Prediction Method

Item	Orbiter		Booster	
	Aerosurf Model	Detailed Analysis	Aerosurf Model	Detailed Analysis
Torque Box	20163	17523	26091	26820
Leading Edge	5259	5272		
Secondary Struct.	2286	2286		
Control Surfaces	3044	3634		
Contingency*	Incl.	2872	Incl.	Incl.
	30752	31587	26091	26820

* The AEROSURF Model is correlated to past aircraft designs and therefore "contingency" is inherently included.

C.3.2 Tail Group - The Aerosurface program (AEROSURF) has also been used for preliminary weight estimates and scaling of Orbiter and Booster tails. Comparisons of the AEROSURF predicted weights to detailed calculations for the current designs are shown in Table C.3-2. The calculated Delta Orbiter vertical tail weight is within 3.3 percent of that predicted by AEROSURF and the Booster vertical tails correlated quite well on earlier checks. Due to time limitations , the final "lazy K " booster tail design was not re-run on AEROSURF.

Table C.3-2
Comparison of Tail Weights from Detailed Analysis to Those from Aerosurface Weight Prediction Model

Item	Orbiter		Booster	
	Aerosurf Model	Detailed Analysis	Aerosurf Model	Detailed Analysis
Torque Box	3128	2649		
Leading Edge	731	731		
Rudder	1080	1260	*	*
Contingency	Incl	464		
	4939	5104		

* Earlier checks showed good correlations but final booster tails were not re-run on AEROSURF

C.3.3 Integral Tankage - Integral tank weight has been plotted versus tank volume in Figure C.3-1 for a number of existing launch vehicle stages. In many cases tank volumes were not available and so, for consistency, volume has been estimated as total propellant load divided by propellant bulk density. Delta Orbiter and Canard Booster tanks are also plotted and agree quite well with the historical data. The tank weights and volumes shown on Figure C.3-1 are summarized in Table C.3-3.

Table C.3-3 Propellant Container Data

Vehicle	Propellant Load - Lb	Propellant Bulk Density -Lb/cu.ft.	Propellant Wt. / Bulk Density - Cu.ft.	Tank Weight -Lb
SIV	101100	20.1	5030	3916
SII	938700	20.1	46700	32830
SIVB	236000	20.1	11740	9133
SIC	4423300	63.0	70200	69532
Titan II (1st stg)	248700	74.8	3330	2830
Titan II (2nd stg)	58500	74.2	788	775
DM-21 (Thor)	100000	63.0	1590	1699
SIA	808894	63.0	12800	19582
Delta Orbiter	526257	20.1	26200	20648
Canard Booster	3038600	20.1	151200	102261

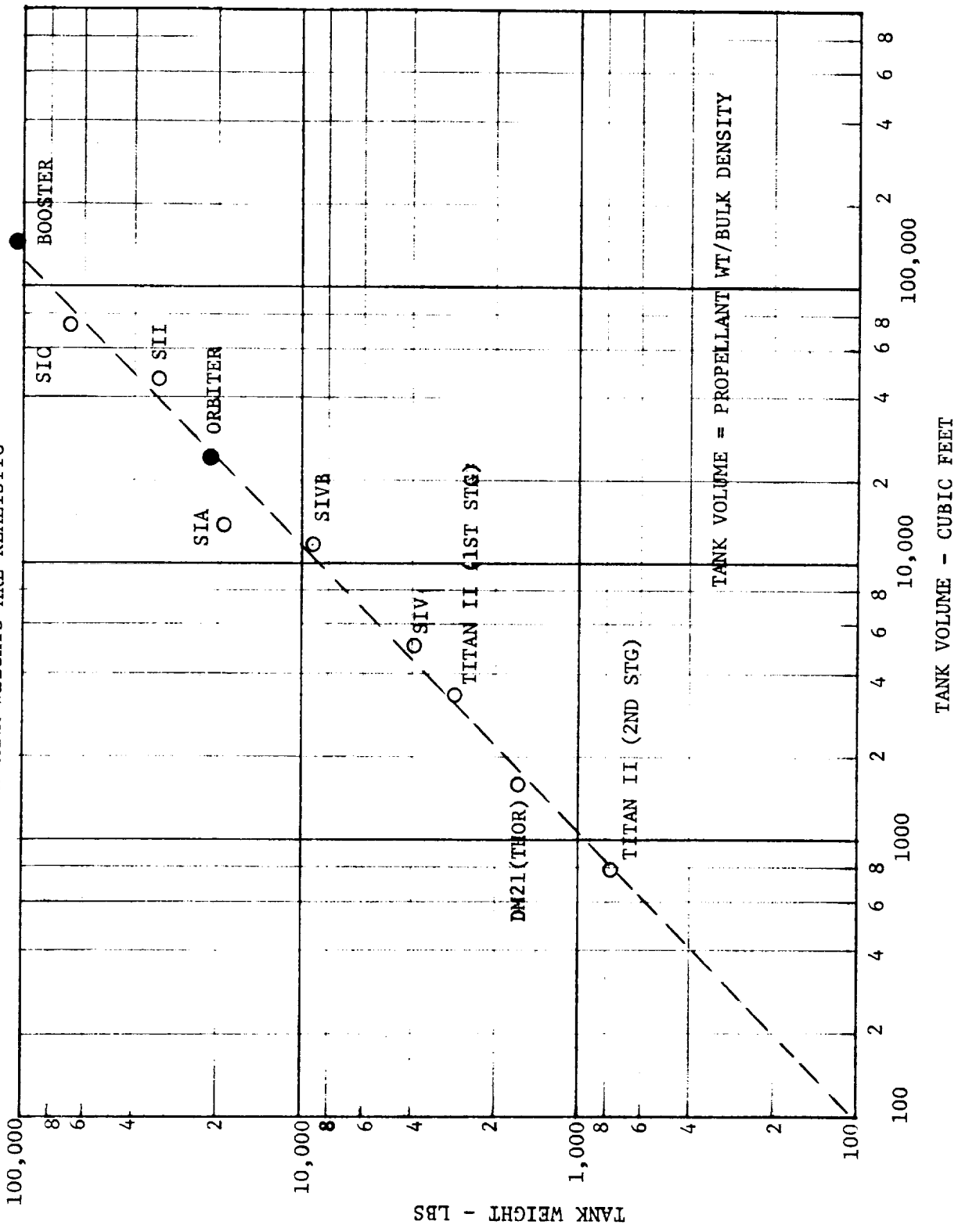
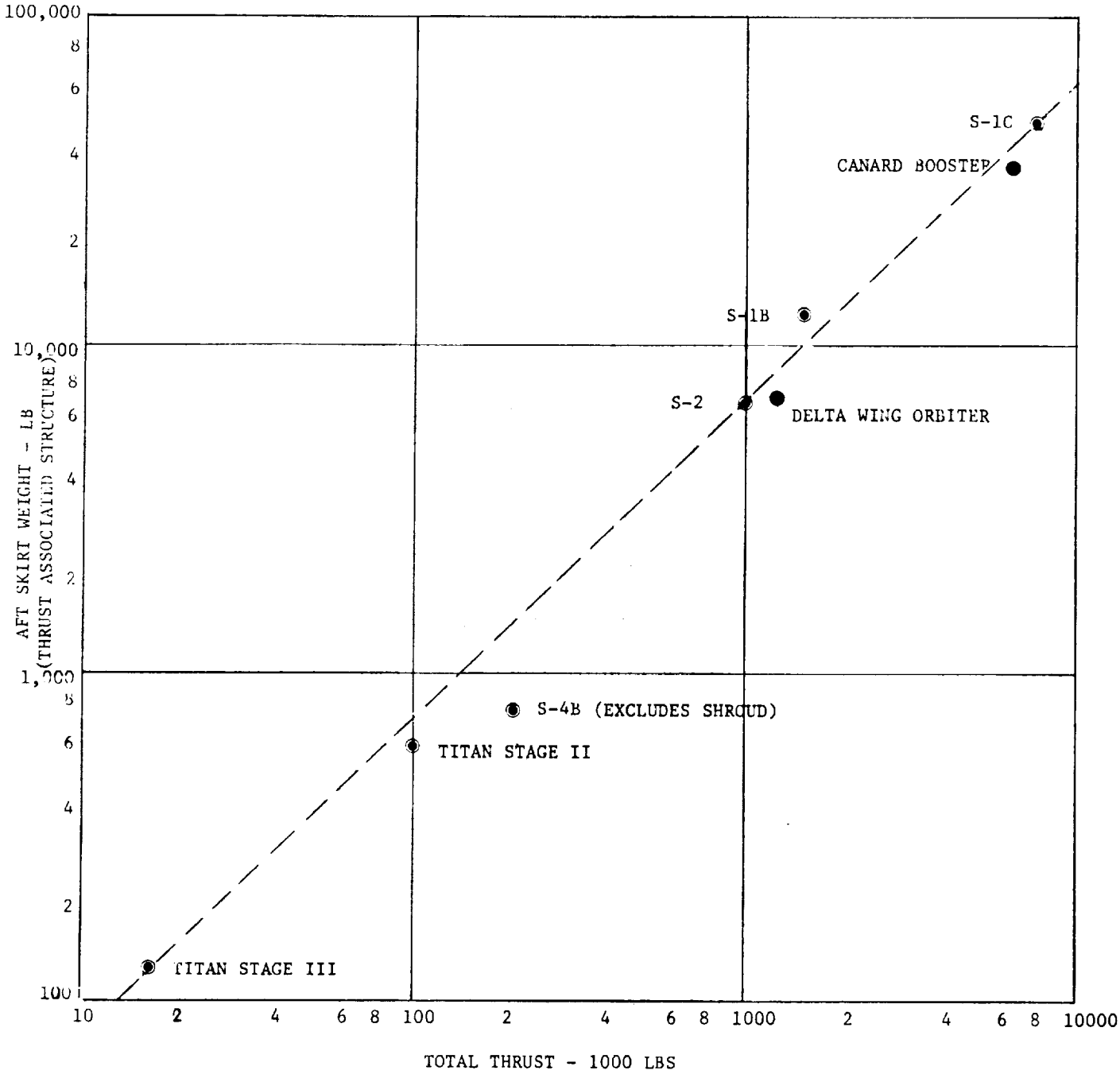


FIGURE C.3-1
ORBITER AND BOOSTER TANK WEIGHTS ARE REALISTIC

FIGURE C.3-2 THRUST STRUCTURE WEIGHT IS REALISTIC



C.3.4 Thrust Structure/Aft Skirt - Thrust structure weight is shown in Figure C.3-2 as a function of total vacuum thrust for the Orbiter and Booster plus a number of actual hardware designs. The current Orbiter and Booster detailed point designs fall below a trend line through the historical data. This is considered reasonable because the current thrust structure/aft skirt design is based on the use of composite materials and high strength to weight alloys and reflects approximately a 10 year state of the art advance over most of the historical data.

C.3.5 Aerodynamic Surface Weight Prediction Method (AEROSURF) - This aerodynamic surface weight prediction method was originally developed by J. J. Morgan of MDAC. It is in essence an analytically derived wing weight equation which has been adjusted to fit actual past hardware designs. Bending material, shear material and rib weights are estimated as a function of geometry, load and material properties. In addition increments are included for stiffness, joints and standard gages. Since its inception, this method has been progressively refined to more accurately reflect load distributions, better fit available past hardware data etc. The current method, including the equations and supporting derivations is presented below. The correlation of this method with actual hardware is even slightly better than shown in Figure C.3-3 because this plot has not been updated to pick up recent minor refinements in some of the equations. A description of AEROSURF follows.

C.3.5 (Cont.)

SYMBOLS

a_i - Rib spacing

A - Area

AR - Aspect Ratio

b - Span

C - Chord length

C_B - Intercept or bending shell unit weight units of lbs/ft, $C_B a_i$ = psf

E - Modulus

f - Stress

F - Allowable stress

F_A - Artificial allowable stress

h - Depth

$k_{\ell c_p}$ - Correction factor to airload distribution

$k_{\lambda m}$ - Integration factor for planform and thickness taper

L - Surface Load

ℓ - Length

M - Moment

m - Thickness ratio

N_Z - Normal load factor x factor of safety

P - Load, lbs

p - Unit loading, lbs/in. or lbs/sq.in.

$\bar{t}$ - Equiv or "smeared" skin thickness

t - Skin thickness

$\bar{w}$ - Unit weight

W - Weight

ρ - Density

η - Fraction of span, exposed semi-span

$\bar{\eta}$ - c.p. location as fraction of length

λ - Planform taper ratio

Λ - Sweep angle

θ - Sweep angle of structural axis (normally .50 c)

τ - Allowable shear stress

C.3.5 (Cont.)

SUMMARY

The Aerodynamic Surface Weight prediction method (AEROSURF) is based on the concept of a basic wing plus increments for special design features and shows good correlation to existing wing and tail surfaces. The major element is the torque box model which consists of:

(a) An airload model for load on exposed surfaces and root bending moment based on the method outlined in RAE transonic data Memorandum 6403 (Reference (h)).

(b) The structural arrangement is a closed two spar multirib box subjected to vertical shear and bending moments. A straight constant section body carrythrough is also computed. Cover skins are analyzed for bending load, spar webs for vertical shear load and ribs for flexure induced crushing load or cover skin stiffness.

(c) The unit weight to load relationship for the cover skins and ribs is developed from a beam column analysis of a single face corrugation panel. A straight line approximation of the calculated curves is used as suggested by Shanley, Reference (b).

(d) The loading and section areas along the span are integrated into total wing weight by analytical expressions. If significant geometry breaks exist a tabulated multistation analysis is employed.

(e) Allowances are included for specific factors that are known but not easily quantified. An overall torque box contingency factor of 20% is developed from correlations to some 25 existing aircraft. These aircraft include a variety of fighters, transports, and bombers assuring the model is valid for a wide range of loading, geometry, and structural arrangements.

AEROSURF is a significant first generation effort at prediction of a wing (or tail) weight with minimum turn around time and effort. It contains a realistic representation for the significant elements of a traditional design cycle and, with the correlation factors, gives accurate quantitative answers as well as correct trends. It is recognized that the model is not truly representative of structural arrangements of typical low Aspect Ratio delta wings yet the correlation with existing delta's and apparent agreement with preliminary analysis of Shuttle wings suggests the overall weight is valid.

INTRODUCTION

Aerodynamic Surface weight prediction has been the subject of many technical reports, studies, and discussions. Empirical methods as well as sophisticated structural analyses have been proposed and are in use. AEROSURF employs elements of both in obtaining a rapid method practical for advanced design parametric usage with sufficient analytical basis to insure validity for a wide range of loading and geometry characteristics. It also defines the elements of a surface in sufficient detail that the results of detail design studies can be easily evaluated and incorporated.

FIGURE C.3-3 GOOD CORRELATION IS OBTAINED OVER A WIDE RANGE OF GEOMETRY AND LOADINGS
(Estimated weight is shown without the non-optimum factor)

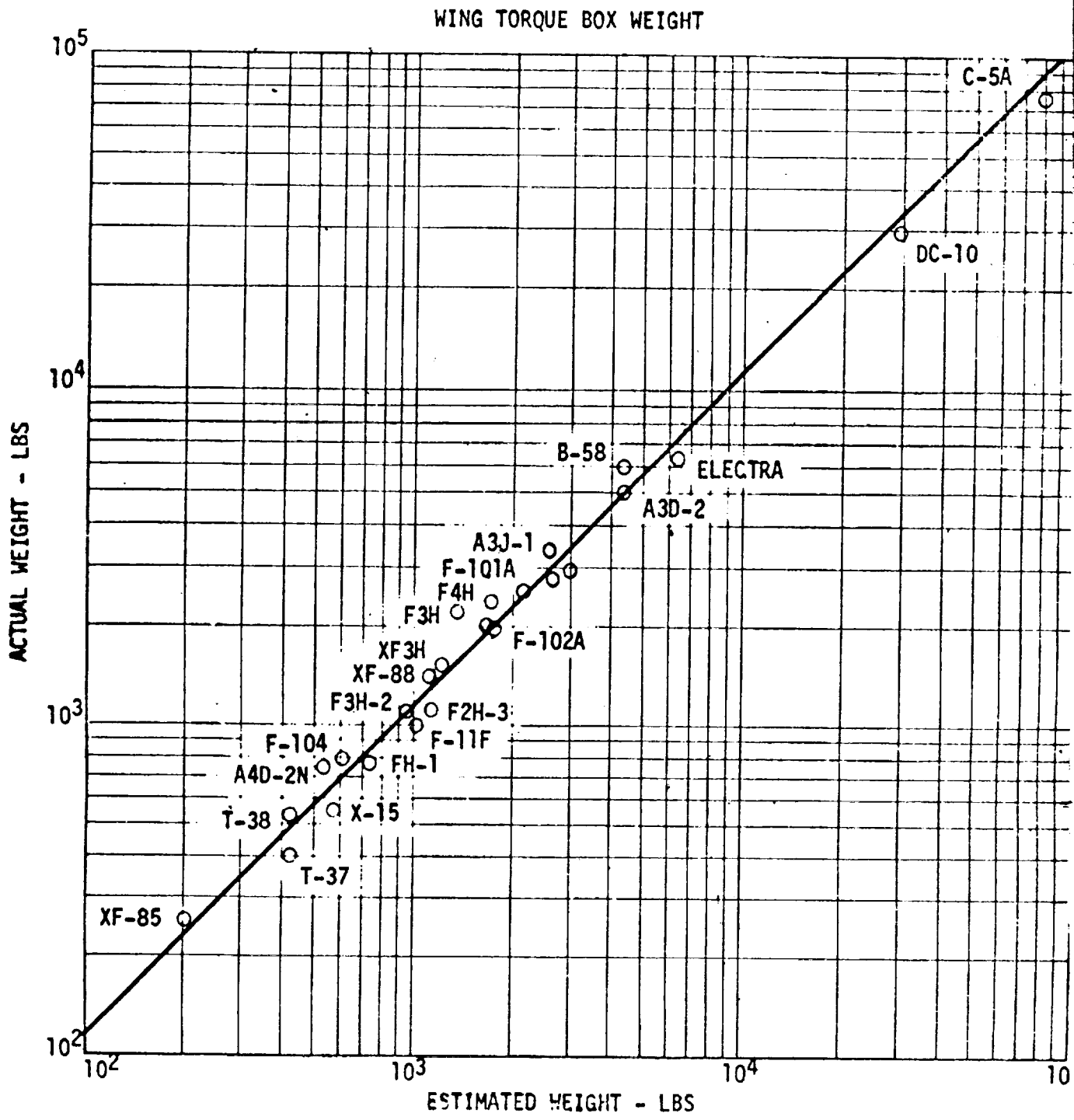


TABLE 1-1

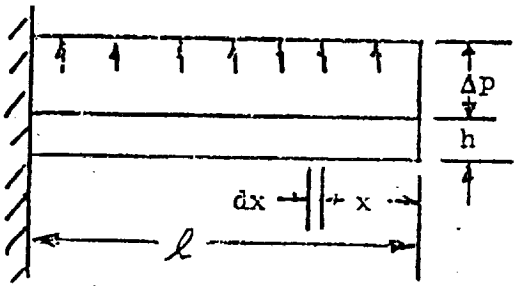
SUMMARY EQUATIONS

	Exposed Surface (ex)	Carrythrough (f)
Bending		
Shell	$\gamma_1 = C_B\, a_i\, k_{t_b}\, S_{e_x}$	$\gamma_2 = 2\, C_B\, a_i\, k_{t_b}\, C_f\, b_f$
Bending	$\gamma_3 = \dfrac{\rho\, L_{e_x}\, k_{\lambda_m}\, k_{\ell_{cp}}}{3\, F_A\, .8 t_f} \left(\dfrac{b_{e_x}}{2\cos\theta}\right)^2$	$\gamma_4 = \dfrac{\rho\, k_{\ell_{cp}}\, L_{e_x}\, b_{e_x}\, (2\lambda' + 1)\, b_f}{6\, F_A\, .8\, t_f\, (\lambda' + 1)}$
Shear		
Intercept	$\gamma_5 = \dfrac{2\, \rho\, C_s\, (.8t_f)^2\, b_{e_x}(m'^2 + m' + 1)}{3\cos\theta}$	$\gamma_8 = 2\, C_B\, .8t_f\, b_f$
Shear	$\gamma_6 = \dfrac{k_{\ell_{cp}}\, L_{e_x}\, b_{e_x}\, (2\lambda' + 1)}{6 r_A \cos\theta\, (\lambda' + 1)}$	
Min gage	$\gamma_7 = \dfrac{\rho\, t_{min}\, .8t_f\, b_{e_x}\, (m' + 1)}{\cos\theta}$	
Ribs		
Strength	$\gamma_9 = 2\rho \int_0^{b/2\cos\theta} \bar{t}_{r_x}\, t_x\, C_x\, \dfrac{1}{a_i}\, d_x$	$\gamma_{10} = \dfrac{2\rho}{a_i}\, \bar{t}_{r_x}\, t_f\, C_f$
	$\bar{t}_{r_x} = C_B\, t_x + \dfrac{2\, (M_x/C_x\, t_x)^2\, a_i}{F_A\, E\, t_x \left(\dfrac{M_x}{C_x\, t_x\, F_x}\right)}$	Where $\bar{t}_{r_x}$ is same as γ_9
Stiffness (if larger than strength)	$\bar{t}_{r_x} = \dfrac{67.5\, M_x}{\pi^2\, E\, C_x\, a_i}$	
Standard Gage	$\gamma_{11} = .14\, S_t\, b_{e_x}$	$\gamma_{12} = .14\, S_t\, b_f$
Simple Model	$\gamma_{13} = .10\, \gamma_3 + .20\, (\gamma_5 + \gamma_6)$	$\gamma_{14} = .10\, \gamma_4$
Joints	$\gamma_{15} = (\gamma_1 + \gamma_3 + \gamma_5 + \gamma_6 + \gamma_7 + \gamma_9 + \gamma_{11} + \gamma_{13}).10$	$\gamma_{16} = (\gamma_2 + \gamma_4 + \gamma_8 + \gamma_{10} + \gamma_{13} + \gamma_{14}).10$
Sub Total	$\gamma_{17} =$	$\gamma_{18} =$
Non Opt	$\gamma_{19} = \gamma_{17}\, (.2)$	$\gamma_{20} = \gamma_{18}\, (.2)$
Sub Total	$\gamma_{20} =$	$\gamma_{21} =$
Relief	$\gamma_{22} = \dfrac{\rho\, W_c\, \ell'^2}{F_A\, .8\, h_f}\, k_m$	$\gamma_{24} = \dfrac{\rho W_c\, \ell'\, \cos\theta\, b_f}{F_A\, .8\, h_f}$
	$\gamma_{23} = \dfrac{\rho W_c\, \ell'}{r_A}$	
Sub Total	$\gamma_{25} = \gamma_{20} - \gamma_{22} - \gamma_{23}$	$\gamma_{26} = \gamma_{21} - \gamma_{24}$
TOTAL	$\gamma_{27} = \gamma_{25} + \gamma_{26}$	

C.3.5 (Cont.)

BASIC ANALYSIS MODEL

The basic analysis model for the torque box is a simple bending beam.



The weight of the beam is the sum of the section unit weights ($A_x\ d_x$).

$$W = \int_0^{\ell} \rho\, A_x\, d_x$$

Assuming both caps are equal and applied stress = allowable stress, the cross sectional area of the beam at x is:

$$A_x = \frac{2\ p_x}{f} = \frac{2\ M_x}{f\ h} = \frac{\Delta p\ x^2}{f\ h}$$

The total beam weight can then be obtained by tabular setup and summation, the multistation analysis method proposed by Kirkpatrick (Reference (j)). For surfaces with no discontinuities the summations are performed with analytical expressions because they are quickly solved and lend themselves to use in parametric studies. Letting $\Delta p \ell$ = total load L, the simple beam expression becomes

$$W = \frac{\rho}{f} \int_0^{\ell} \frac{\Delta p\ x^2}{h}\, dx = \frac{1}{3}\ \frac{\rho\ L \ell^2}{f\ \ h}$$

The weight equations for a wing are developed as follows:

- o from the load model, calculate the shear and bending material at a section
- o determine the unit cap or web loading
- o from the structural model and unit loading calculate the section area
- o integrate the section areas over the span to obtain total weight
- o add factors for unanalyzed material and correlate to existing vehicles
- o develop expressions for a geometric break at the wing-fuselage attachment.

C.3.5 (Cont.)

AIRLOAD DISTRIBUTION

Spanwise c.p. - The variation in spanwise location of the center of pressure with planform taper ratio λ, sweepback angle Λ, and Aspect Ratio AR, is derived from the method of RAE Transonic Data Memorandum 6403, Reference (h) which is based on Multhopp's subsonic lifting surface theory. Planforms with curved leading edges and arbitrary trailing edges can be estimated by data presented in Reference (h) Figure C.3-4 presents the spanwise c.p $(\bar{\eta})$ of surfaces with straight leading and trailing edges as a function of λ, Λ, and AR.

Surface Load - The wing in conventional airplane mode flight must have a lift equal to the aircraft weight times its load factor plus the balancing tail load, normally a down load. However, the wing weight provides an inertia relief load reducing the bending moments on the wing. The basic beam analysis model with a uniform load distribution and a triangular bending material weight distribution defines an inertia relief integration factor of 1/2 for the wing weight. The wing load is therefore

$$L_w = (W_g - 1/2\ W_w)\ N_Z \pm L_H.$$

Launch loads, normally critical for Shuttle wing design, are calculated separately and input.

Body Lift - The method presented applies only to wings. At low angles of attack the effect of the fuselage or nacelle is probably not critical, thus body lift is calculated directly from the method outlined in Reference (h). The loading at the centerline (η_o) and at the wing/fuselage attachment (η_f) is calculated as follows:

$$\frac{CC_L}{\bar{C}\bar{C}_L} = F(\eta\bar{\eta}) + G(\eta) + H(\eta)$$

where

$$F(\eta\bar{\eta}) = (3.395 - 5\bar{\eta})\sqrt{1 - \eta^2} + (20\,\bar{\eta} - 8.488)\,\eta^2 \sqrt{1 - \eta^2}$$

$$G(\eta) = (AR\ \mathrm{Tan}\ \Lambda\ te)\left[- .01484\ (1 - 6.666\,\eta + 7.316\,\eta^2)\ \sqrt{1 - \eta^2}\right]$$

$$H(\eta) = (AR - 4)\ (1 + 3.5\ \mathrm{Tan}\ \Lambda\ te)\left[.033(1 - 14.5\eta^2 + 21\eta^4)\ \sqrt{1 - \eta^2}\right]$$

Note if AR $\leq$ 4 $H(\eta) = 0$

The load carried on the body is calculated as the average loading times body span.

C.P. of Exposed Surface Lift - The body lift c.p. is calculated assuming a straight line distribution between lift at η_o and η_f. Knowing the c.p. of the total lift, the c.p. of the exposed surface lift (η_{ex}) is calculated and referenced to exposed span

$$\eta_{ex} = \left[\frac{L_\eta - L_f\,\eta_f - L_{ex}\,\eta_f}{L_{ex}}\right]\frac{\eta}{\eta_{ex}}$$

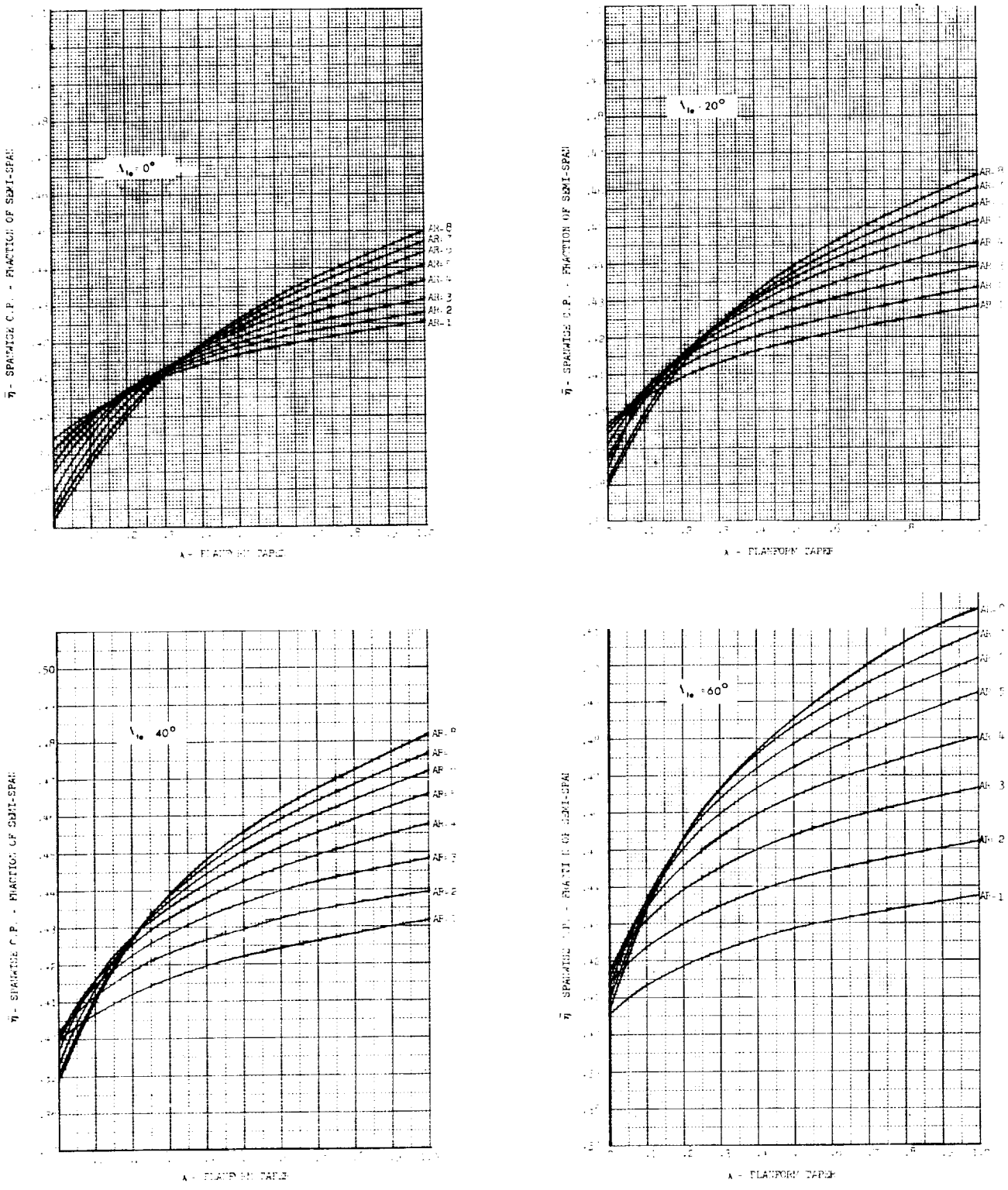


FIGURE C.3-4 SPANWISE LOADING (RAE #6403)

C.3.5 (Cont.)

Load Distribution on Exposed Surface - The calculation of loading across the exposed span by the method of Reference (h) does not lend itself to simple equations. Sufficient accuracy for preliminary estimates is obtained by a uniform distribution times a factor ($k_{\ell cp}$) producing the same root bending moment as calculated above. The c.p. of the uniform distribution airload is:

$$\eta_{un} = \frac{1}{3}\left(\frac{2\lambda' + 1}{\lambda' + 1}\right)$$

The load distribution factor, $k_{\ell cp}$, is simply

$$k_{\ell cp} = \frac{\bar{\eta}_{ex}}{\bar{\eta}_{un}}$$

The loading at $x = \Delta p\left[C_t X + (C_f - C_t)\frac{X^2}{b_{ex}}\right]$

where: $\Delta p = \frac{L_{ex}}{S_{ex}} = \frac{2\,L_{ex}}{b_{ex}\,C_f\,(1 + \lambda')}$ where L_{ex} = load on both surfaces

The moment along the exposed span is:

$$M = k_{\ell cp}\,\frac{L_{ex}}{2}\,\frac{b_{ex}}{2}\left\{\frac{1}{3}\left[\frac{3\lambda'(\eta)^2 + (1 - \lambda')(\eta)^3}{1 + \lambda'}\right]\right\}_0^{1.0}$$

where η = faction semispan = $x/b_{ex/2}$ = 0 at tip

The moment at the root is:

$$M = k_{\ell cp}\,\frac{L_{ex}}{2}\,\frac{b_{ex}}{2}\,\frac{1}{3}\left(\frac{2\lambda' + 1}{\lambda' + 1}\right)$$

Sweepback and Carrythrough - A swept surface is evaluated in the same manner as a straight wing except that structural span relpaces aerodynamic span in the calculation of bending moment and the integration is performed along the structural span. Unless known, use the .50 chord line, θ, as the structural axis. The structural span is $b_{ex/2}$ Cos θ.

The carrythrough is assumed to be a straight, constant thickness section through the body. The vertical shear is reacted at the wing fuselage attachment thus the carrythrough bending moment is constant and is based on aerodynamic span.

SECTION BENDING LOADS

Surface Thickness - The thickness along a span with a straight taper is:

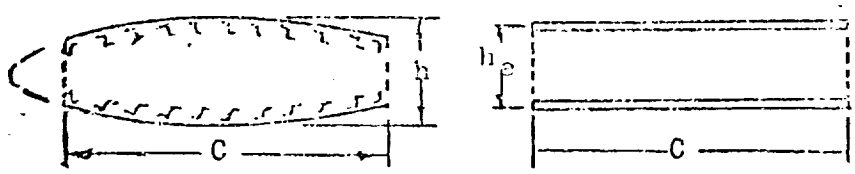
$$t_x = \frac{t_f}{b_{ex}/2}\left[m' \frac{b_{ex}}{2} + (1 - m')\, x\right]$$

where:

$$m' = t_t/t_f$$

$$t_f = \frac{t_r}{b}\left[mb + (1 - m)\, b_f\right]$$

Effective Thickness - The analysis model assumes all bending loads are carried in the cover skins. The wing structure is considered a two flange beam with the centroids of the flanges separated by the distance, h_e.



Representation of Wing by equivalent two flange beam

The ratio between the effective depth, h_e and the maximum depth is k_e. Shanley has investigated the effective depth factor variation with length and location of the box and the thickness of the flange material for several airfoils (Reference (b)). Based on this work a nominal value of k_e .8 is used. This should be reevaluated for any new class of surfaces being examined and modified as required.

Cap Loads - The cap load, P_x, at any section is obtained by dividing the moment M_x, by the thickness, t_x.

$$P_x = \frac{M_x}{t_x}$$

$$= \frac{k_{\ell cp}\, \frac{L_{ex}}{2}\, \frac{b_{ex}}{2\cos\theta} * \frac{1}{3}\left(\frac{2\lambda'\eta^2 + (1 - \lambda')\eta^3}{1 + \lambda}\right)}{t_f\left[m' + (1 - m')\right]}$$

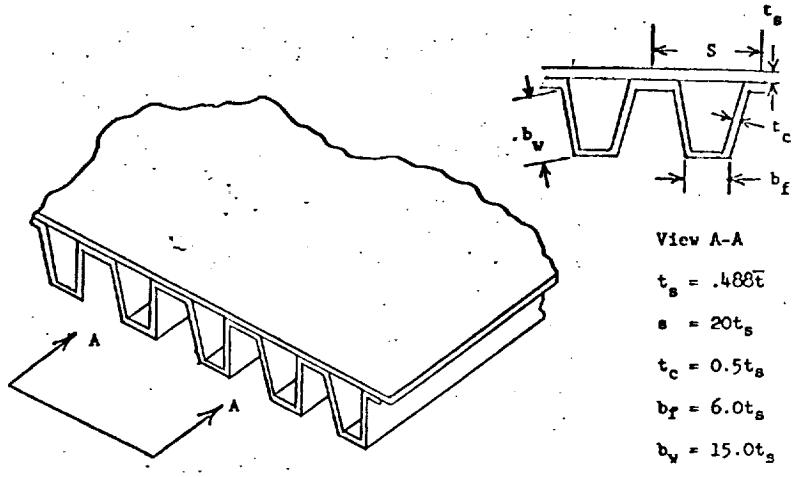
at the wing-fuselage intersection

$$P_f = \frac{k_{\ell cp}}{t_f}\, \frac{L_{ex}}{2}\, \frac{b_{ex}}{2\cos\theta} * \frac{1}{3}\left(\frac{1 + 2\lambda'}{1 + \lambda'}\right)$$

STRUCTURAL MODEL-BENDING MATERIAL

Cover Loads - The cover skins of an aerodynamic surface are usually subjected to longitudinal compression from spanwise bending, lateral compression from chordwise bending and shear from torque. A rapid and logical method of obtaining and interacting the failure stresses from the three loadings is not known. AEROSURF assumes the spanwise bending stresses are critical.

Cover Skin Allowable - For the weight equations the cover skin allowable stress is determined from an analysis of a single skin, open face corrugation shell. This concept is chosen for ease of analysis and the belief that the desired thickness to load relationship is reasonably typical for most structural configurations. Analysis is based on sizing model geometry shown on right.



View A-A

$t_s = .488\bar{t}$

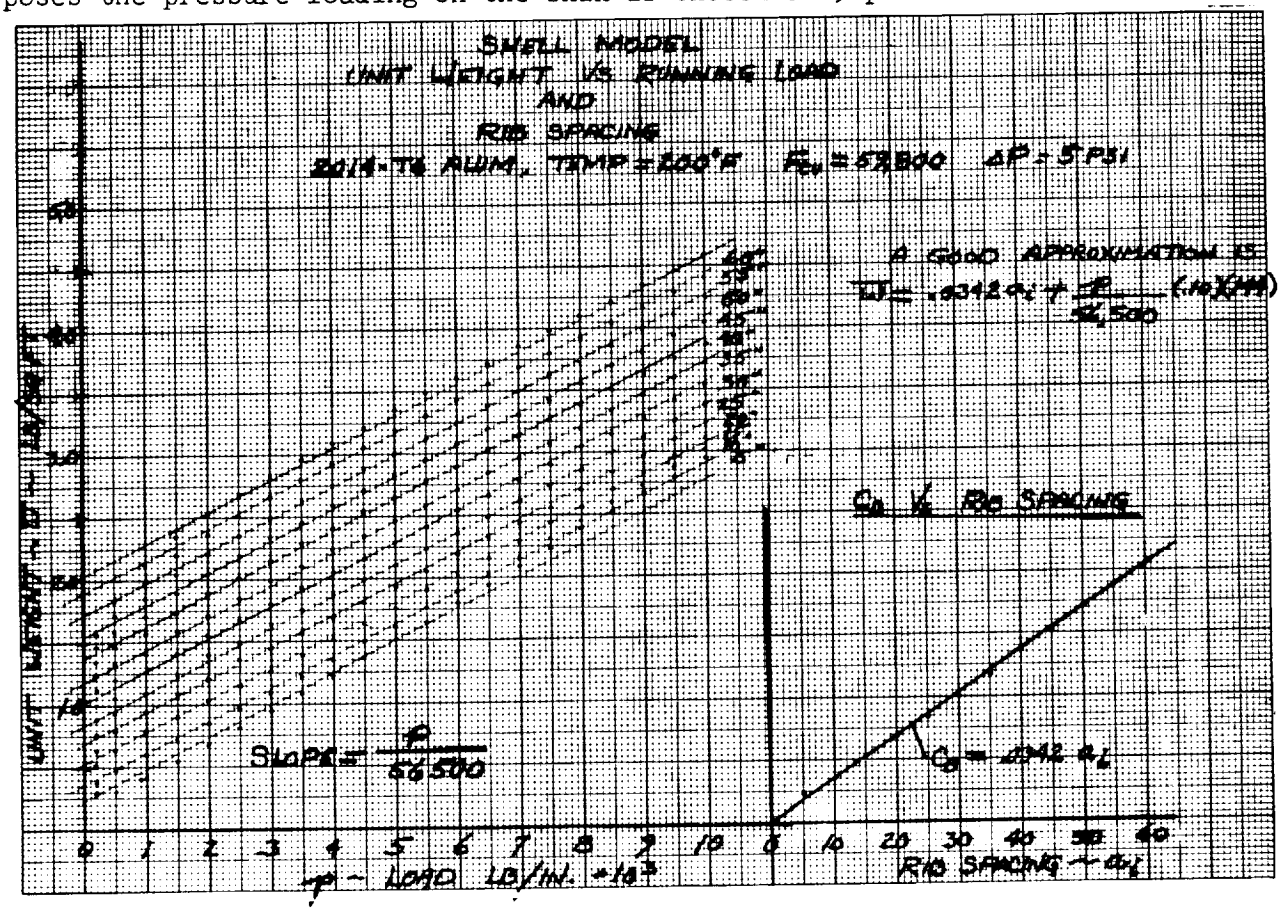
$s = 20t_s$

$t_c = 0.5t_s$

$b_f = 6.0t_s$

$b_w = 15.0t_s$

The analysis of the single face corrugation shell is taken directly from the beam-column analysis presented in Reference (i). A beam column is a compression member which is also subjected to bending loads. The corrugations are analyzed as though each pitch acts as a beam column. The beam column length is equal to the interval between frames. Boundary conditions consider negligible loop tension in the shell skin and end-fixity to be fully fixed. For analysis purposes the pressure loading on the skin is chosen as 5 psi.


SHELL MODEL
UNIT WEIGHT VS RUNNING LOAD
AND
RIB SPACING
2014-T6 ALUM. TEMP = 200°F
F_{cy} = 52,500
ΔP = 5 PSI
UNIT WEIGHT - LBS/SQ FT
SLOPE = $\frac{P}{52,500}$
C_R VS RIB SPACING
C_R = .2942 a_L
0 1 2 3 4 5 6 7 8 9 10 0 10 20 30 40 50 60
P - LOAD LB/IN. ÷ 10³
RIB SPACING - a_L

C.3.5 (Cont.)

The skin thickness ($\bar{t}$) or unit weight ($\bar{w}$) is computed for various load intensities and plotted for the specific material and temperature under consideration. Straight line approximations of the curves are developed following the approach of Shanley, Reference (b). The equations have the form of:

$$\frac{\bar{w}}{\rho} \text{ or } \bar{t} = C_B + \frac{p}{F_A}$$

where: C_B is the intercept value or "shell" weight

F_A is an artificial allowable stress for the unit load, p

The C_B term has a direct relationship to column length (rib spacing for cover skins) as shown in Figure 6-1 where a specific aluminum alloy

$$\bar{w} = .0342\ a_i + \frac{p}{56500}\ (.10)(144)$$

Note that a good fit is obtained for loadings from 1000 to 10000 pounds/inch and rib spacing from 10 to 60 inches. Consideration is given to insuring that C_B is equal or greater than minimum gage and that F_A does not exceed F_{tu}. In correlations to existing aircraft where the particular alloy is not known values of $C_B = .0525\ a_i$ and $F_A = 128{,}000$ are representative values for titanium and $C_B = .035\ a_i$ and $F_A = 61000$ are representative values for aluminum.

Compression vs. Tension Cover - The beam model places the upper cover in compression and the lower cover in tension. It could be anticipated that the lower cover with the higher tension allowables would be lighter than the compression cover. The detail weight statements of a variety of aircraft fail to show this trend. In fact the covers are similar in weight with no consistent pattern as to which is the heavier. AEROSURF considers the weight of the lower "tension" cover equal to the upper "compression" cover.

EQUATIONS FOR BENDING MATERIAL

Basic Beam Model - The basic weight of a beam was shown above to be:

$$W = \rho \int_0^{\ell} A_x\, d_x = \frac{1}{3} \frac{\rho\, L\, \ell^2}{f\ h}$$

Combined Planform and Thickness Taper - A conventional surface is tapered in both planform and thickness. The integration factor for the combined effect is derived as follows:

$$W = \frac{2\rho}{f} \int_0^{\ell} \frac{M_x}{h_x}\, d_x$$

C.3.5 (Cont.)

where

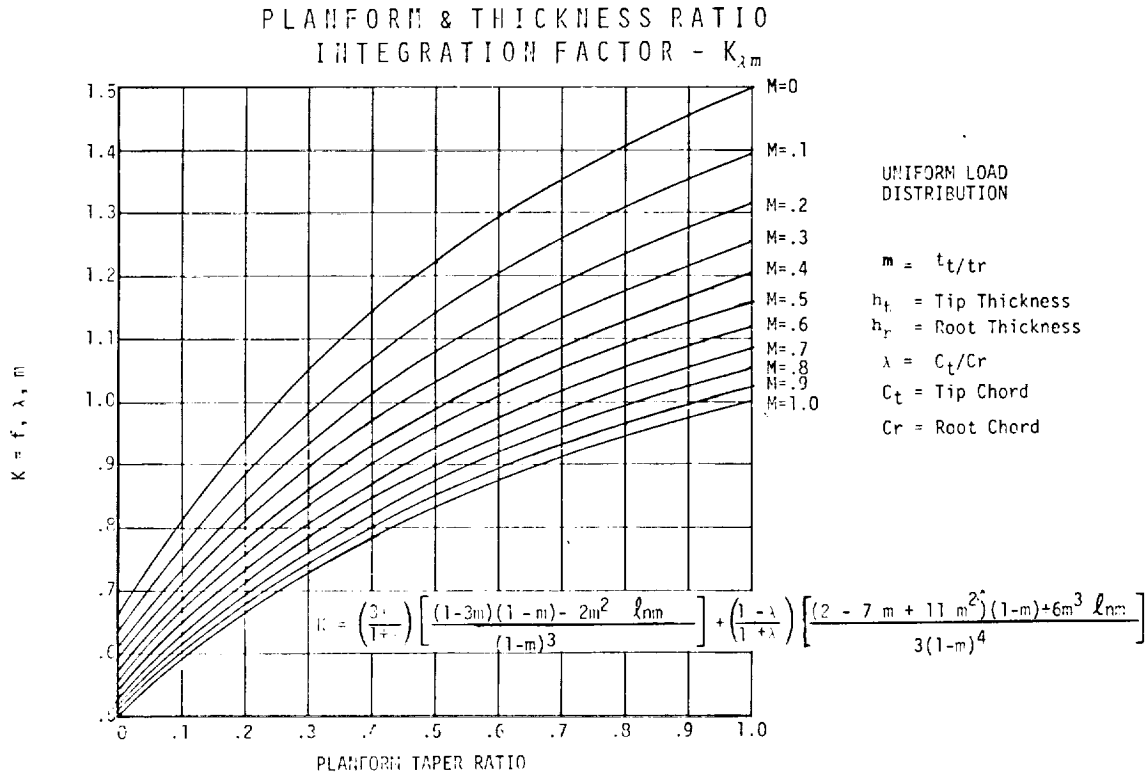
$$M_x = \Delta p \; C_f \left[\frac{\lambda' x^2}{2} + \frac{(1 - \lambda')\, x^3}{6\ell} \right]$$

$$h_x = \frac{h_f}{\ell} \left[m'\ell + (1 - m'')x \right]$$

solving

$$W = \frac{1}{3} \frac{\rho \, L \ell^2}{f \, h_f} \; k_{\lambda m}$$

- The integration factor, $k_{\lambda m}$, is:



Equation Development - The structural model unit weight is

$$\bar{w} = \bar{t}\,(.10)(144) = C_B + \frac{p}{F_A}\,(.10)(144)$$

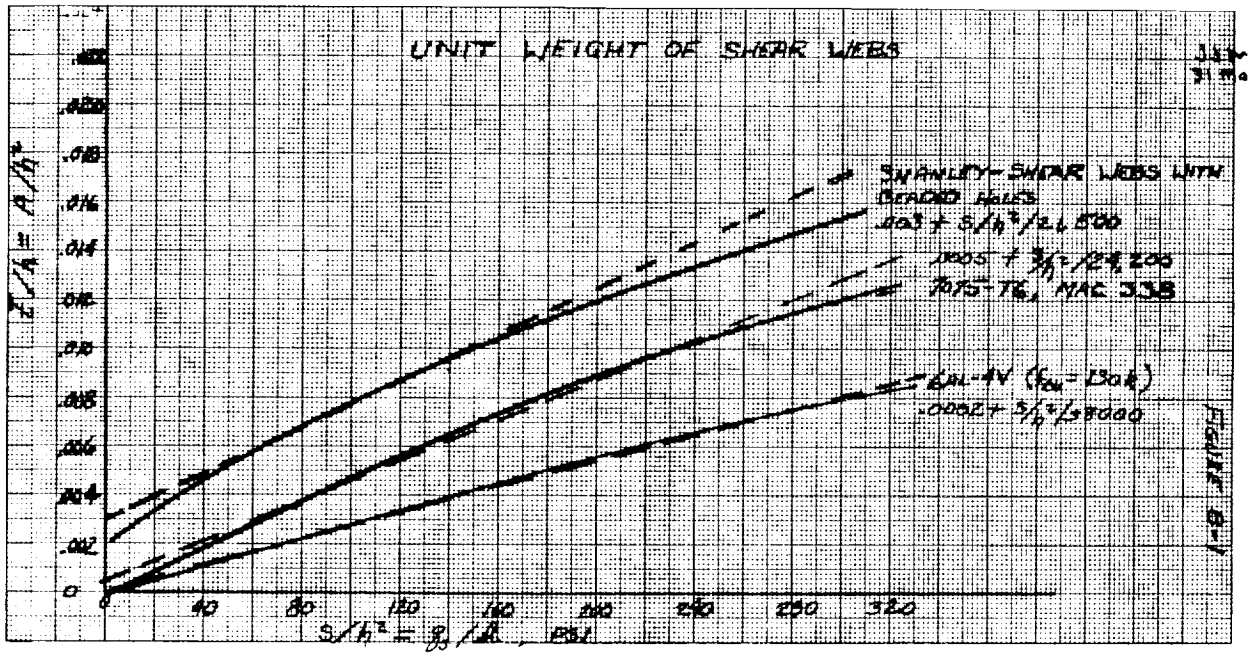
The shell portion (C_B) is independent of load and a function only of rib spacing. The second term, is the same as the A_x term of the basic beam model.

The shell portion is a function of rib spacing. References (g) and (f) suggest the optimum rib placement is near $e_{i_x} = h_x$ and that the total weight is relatively insensitive to rib spacing. AEROSURF uses rib spacing as constant along the structural axis with spacing equal to h at .8 $b_{ex/2}$ and a minimum spacing of 10 inches.

SHEAR MATERIAL

Structural Model - The structural model has the vertical shear carried by two spars. Torque is not considered and the spars do not contribute to cover stability. An expression similar to Shanley's (Reference (b)) shear stress model is developed for AEROSURF using the tension field analysis of Reference (c).

The weight/load curves developed for typical aluminum and titanium webs are:



A minimum gage web is added since the intercept term may not reflect a minimum gage. Typical values are:

titanium $C_S = .0002$, $\tau_A = .29\ F_{tu}$, $t_{min} = .02$

aluminum $C_S = .0005$, $\tau_A = .29\ F_{tu}$, $t_{min} = .03$

Loading - The area of two shear webs at a section is:

$$A_x = 2\ t_{min}\ (.8\ h_x) + 2\ C_s\ (.8\ h_x) + S_x/\tau_A$$

where

$$S_x = \Delta p\ C_f \left[\lambda' X + (1 - \lambda')\ X^2/b_{ex}\right]$$

C.3.5 (Cont.)

The load distribution factor $k_{\ell cp}$ is introduced to provide an artificial measure of the actual load distribution.

Equation Development - Shear material equations are developed in the same manner as the bending material equations.

$$W = 2\rho \int_o^{\frac{b_{ex}}{2\cos\theta}} A_x \, d_x$$

o minimum gage:

$$= \rho t_{min} \; .8 \; h_f \frac{b_{ex}}{\cos\theta} (m' + 1)$$

o shell material:

$$= \frac{2}{3} \rho \, C_s \, (.8h_f)^2 \frac{b_{ex}}{\cos\theta} (m'^2 + m' + 1)$$

c shear material:

$$= \frac{k_{\ell cp} \, L_{ex} \, b_{ex} \, (2\lambda' + 1)}{6 \tau_A \cos\theta \; (\lambda' + 1)}$$

The model considers only vertical shear loads thus there is no shear load in the carrythrough. An arbitrary closure web equal to the bending shell ($C_B \, a_i$) provides an allowance for torque and loads not accounted for in the model.

RIBS

Structural Model - Reference (g) is used as a guide for the rib model. Full depth ribs are assumed.

Two loads are considered in rib sizing, (a) flexure induced crushing load from spanwise bending curvature, (b) stiffness to develop the column strength of the cover.

The flexure induced crushing load on the rib is:

$$N_{n_x} = \frac{2 \, p_x^2 \, a_i}{E \, \bar{t}_{c_x} \, h_x}$$

The stiffness to obtain column strength of the cover is:

$$\bar{t}_{R_X} = \frac{67.5 \quad M_x}{\pi^2 \, E_R \quad C_x \, a_i}$$

Equation Development - The rib weight equation is:

$$W_R = 2\rho \int_0^{b/2 \cos\theta} \bar{t}_{r_x} h_x c_x \frac{1}{e_i} d_x$$

where $\bar{t}_{r_x}$ = larger of $\bar{t}_{r_x}$ or t_{R_x}

$$= \frac{C_B h_x}{(.10)(144)} + \frac{N n_x}{F_A} \quad \text{or} \quad = \frac{67.5 M_x}{\pi^2 E C_x a_i}$$

h_x is used in place of .8 h_x to provide an allowance for the rib attachment structure. Keeping C_B greater than minimum gage is not critical for the rib webs since designs using lightening holes and truss structures are practical approaches.

ALLOWANCES

The total wing structural weight will be different than the "optimum" weight defined by the prediction model. This difference is accounted for by two methods, (a) assessing reasonable values for known items that cannot be quantified by analysis and (b) including an overall non-optimum or contingency factor for the remaining weight difference, this factor being based on correlations to existing surfaces.

Joints - On any built-up structure weight penalties are incurred for joints. Aircraft detail weight statements breakout the identifiable elements of Joints, Splices, and Fasteners (JSF). Reference (d) data and other detail weight statements show the following percentage of torque box weight for JSF.

Aircraft	%	Aircraft	%	Aircraft	%
B47B	6.3	C-135A	22.1	F-104F	5.9
B-52A	7.9	C-133B	6.8	F-100D	13.1
B-58A	8.8	F-105F	6.2	F-4D	7.9
B-36A	8.9	A3J-1	8.8	A-3D-2	9.3
F-8E	7.8	X-15A	6.3	C-5A	8.6
C-119H	13.4	F-5A	10.0	DC-8-63	10.1
KC-130F	8.9	F-101B	15.7	DC-10-10	7.3

No logical trend with any geometry or loading parameters was found. Note that differences in weight grouping may be significant and the values listed are biased, perhaps significantly, to the low side since elements not readily identifiable such as integral doublers, thicker skins or webs, "non-optimum" load paths, overlaps, etc., are not normally included in the JSF grouping. Ten percent of total torque box weight is included for joints.

Standard Gages - Modern aircraft use extensive machining methods, therefore, only a small factor is anticipated for the use of standard gages and not tapering all elements to absolute strength requirements. A thickness of .005 inches per surface appears reasonable for aluminum structure to account for this manufacturing problem. Since titanium and steel will be subjected to even more exotic machining a unit weight of .14 psf is included for all materials.

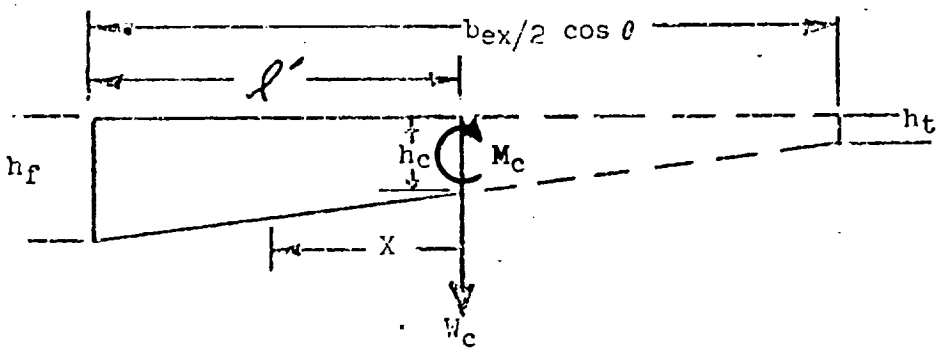
C.3.5 (Cont.)

Simplified Model - The loading condition assumed in the analysis model considers only one flight condition. The multiple loadings on an actual surface, HAA, LAA, Landing, torque, etc., will increase the loads derived by the analysis model on some or all structural elements. Bending material will be affected somewhat, shear webs and ribs to a greater extent. An arbitrary 10% in bending structure, 20% in shear structure and ribs is included to reflect the multiple load conditions.

Contingency - Correlation with existing hardware shows the prediction model defines a weight that is 20% less than the actual surface weight. A contingency factor is added to the model to account for this weight. Comparison of the contingency factor to various geometric and loading parameters failed to show any logical trends, thus there is confidence that the model does reflect actual variations and that realistic data is obtained for designs and loadings significantly different than the correlation points.

CONCENTRATED LOADS AND MOMENTS

Bending Relief - A concentrated weight will normally provide a relieving load to the surface. The weight increment is derived using the basic bending beam model



The weight, per side, is

$$W_{rel} = \int_o^{\ell} \rho A_x \, dx$$

$$A_x = \frac{2 M_x}{f h_x} = \frac{2 W_c x}{f \frac{h_f}{\ell'} \left[m'' \ell' + (1 - m'') x \right]}$$

where $m'' = h_c/h_f$

$f = F_A$ since shell is not changed

Solving

$$W_{rel} = \frac{\rho W_c \ell'^2}{F_A \cdot .8 \, h_f} k_{m''}$$

The total relief term

Weight = (bending exposed + bending carrythrough + shear) JSF

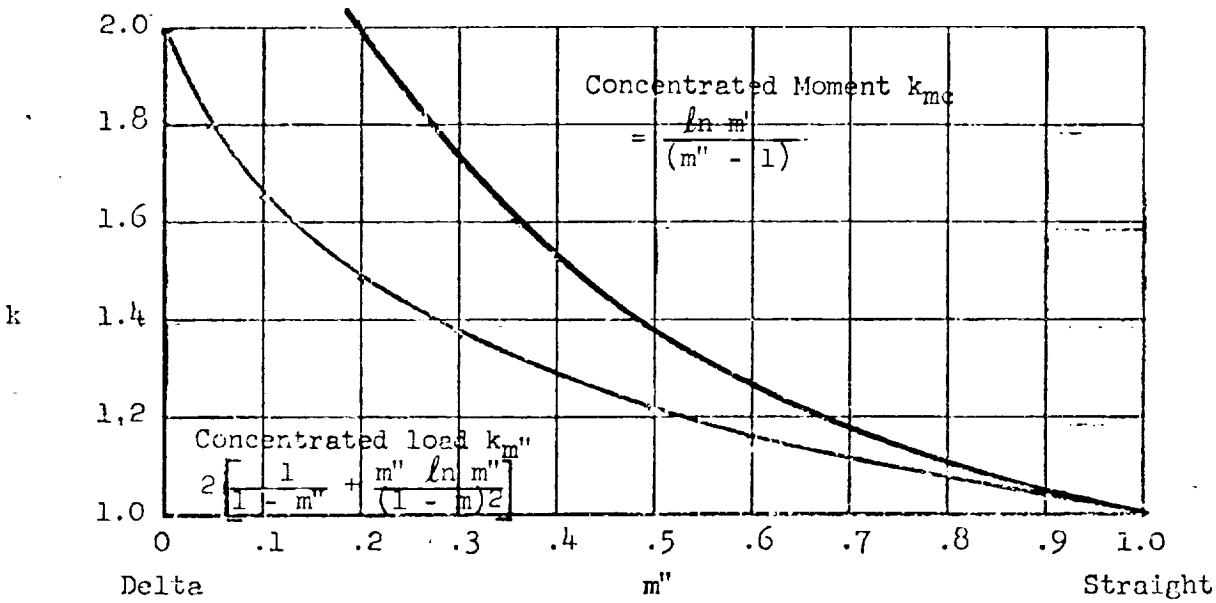
$$W_{rel} = \left\{ \frac{\rho\, W_c\, \ell'^2}{F_A\ .8\ h_f}\, k_{m''} + \frac{\rho\, W_c\, \ell' \cos\theta\ b_f}{F_A\ .8\ h_f} + \frac{\rho\, W_c\, \ell'}{\tau_A} \right\} \quad 1.10$$

Concentrated Moment - The weight increment for a surface including an added moment (fin) is determined as follows:

$$W = 2\rho \int_0^{\ell'} A_x\, d_x = 2\rho \int_0^{\ell'} \frac{2\, M_x}{f\, h_x}\, d_x$$

$$= \frac{4\, \rho\, M_c\, \ell'}{F_A\ .8\ h_f}\, k_{m_c}$$

The integration factors for inertia relief loads and concentrated moments ($k_{m''}$ and k_{mc}) are



CORRELATIONS

The model derived represents the significant elements of a traditional design cycle. Correlation is made to actual aircraft data of a variety of classes and geometry. The weight non-torque box elements, ailerons, gear back-up, flaps trailing edge wing-fold etc. are derived using the MCAIR methods of reference (e). The equation summary and correlation curve of wing torque boxes is shown on Figure C.3-3.

C.3.5 (Cont.)

References used in the above Description of the "AEROSURF" Weight Estimation method are listed below.

a) "Basic Structural Shell Weight Prediction," Weights Note E233-WE&C-7, McDonnell Douglas Astronautics Company-East. (Not released)

b) Shanley, F. R., "Weight-Strength Analysis of Aircraft Structures," Dover Publications, Inc. 2nd Edition, 1960.

c) MAC Report 338, "Structural Analysis Bulletins," McDonnell Douglas Corporation, revised 2 January 1969.

d) "Hypersonic Aerospace-Vehicle Structures Program - Volume II - Generalized Mass Properties Analysis," AFFDL-TR-68-129, Volume II Parts 1 and II, dated January 1969.

e) MAC Report 747, "Weight Estimation Handbook," McDonnell Douglas Corporation (not released).

f) MAC Report 3525, "Optimum Design of Multiweb Beams in Bending," McDonnell Aircraft Corporation, Revised 13 March 1960.

g) "Optimization of Multirib and Multiweb Wing Box Structures Under Shear and Moment Loads," A paper by Emero, Donald H. and Spunt, Leonard, North American Aviation, Inc. Los Angeles Div. presented at the AIAA Conference, 1965.

h) Royal Aeronautical Society, Transonic Data Memorandum 6403, "Method for the Rapid Estimation of Theoretical Spanwise Loading due to a Change in Incidences" Issued March 1964.

i) MAC 339 "Structures Handbook," McDonnell Douglas Corporation, revised 2 January 1969.

j) Society of Aeronautical Weight Engineers Technical Report 73, "Estimation of Wing Bending Material by Multiple Station Analysis," A. L. Kirkpatrick May 1952.

k) "Computer Aided Stabilator Design Including Aeroelastic Constraints," W. E. Tripplet and K. D. Ising, McDonnell Aircraft Corporation. Presented at the 11th Structural, Structural Dynamics, and Materials Conference of AIAA and ASME, Denver Colorado 22-24 April 1970 (MDC 70-006).

C.4 Data Summaries for Selected Vehicles (Using Space Shuttle Format) -

Weight and design data summaries are presented as follows:

- Table C.4-1 - Fighter Aircraft
- Table C.4-2 - Transport Aircraft
- Table C.4-3 - Commercial Aircraft and Bombers
- Table C.4-4 - Spacecraft

These tables are followed by a collection of geometric descriptions of the vehicles for which this data was available.

TABLE C.4-1 DATA SUMMARY (FIGHTER AIRCRAFT)

CONFIGURATION | BY | DATE

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	8717	4314	4537	3125	3000	3615	8398	
2	TAIL GROUP	1802	576	909	701	535	983	1842	
3	BODY GROUP	6548	3551	4655	3283	3409	5954	10873	
4	INDUCED ENVIR PROTECTION								
5	LANDING, RECOVERY, DOCKING	2914	1459	1732	1552	1056	1995	2296	
6	PROPULSION-ASCENT								
7	PROPULSION-CRUISE	11429	6998	9900	11396	6397	8924	10465	
8	PROPULSION-AUXILIARY								
9	PRIME POWER						226		
10	ELECT CONVER & DISTR	904	534	548	752	594	805	839	
11	HYDRA CONVER & DISTR	402	474	613	377	318	460	637	
12	SURFACE CONTROLS	1424	1067	966	671	413	1418	1777	
13	AVIONICS	2305	1118	1789	1176	2142	971	3108	
14	ENVIRONMENTAL CONTROL	324	101	358	136	259	184	570	
15	PERSONNEL PROVISIONS	397	218	476	236	227	262	803	
16	RANGE SAFETY & ABORT								
17	BALLAST					47	186		
18	GROWTH UNCERTAINTY								
19	AUXILIARY GEAR	647	253	500	73	78	93	95	
	SUBTOTAL DRY WEIGHT	37813	20663	26[illegible]83	23476	[illegible]	26076	41703	
20	PERSONNEL	663	200	430	230	230	230	430	
21	CARGO	8711	1238	2290	2442	2455	3758	15623	
22	ORDNANCE								
23	RESIDUAL FLUIDS	280	147	333	219	255	198	406	
24									
	SUBTOTAL INERT WEIGHT	47467	22248	30036	26369	21415	30262	58162	
25	RESERVE FLUIDS								
26	IN FLIGHT LOSSES								
27	PROPELLANT-ASCENT								
28	PROPELLANT-CRUISE	22354	9789	13552	13533	9848	17315	32291	
29	PROPELLANT-MANEUV ACS								
30									
	TOTAL (GROSS WEIGHT)LB.	69821	32037	43588	39902	31263	47577	90453	
	BURNOUT WEIGHT -LB.								
	DESIGN LANDING WT. - LB.	45922	23500	34000	31000	22071	29227	70000	
	WING GROSS AREA - SQ.FT.	812	516	538	368	698	385	525	
	HORIZONTAL TAIL AREA-SQ.FT.	167	82	96	75	0	60	173	
	VERTICAL TAIL AREA-SQ.FT.	175	45	68	85	95	63	112	
	BODY WETTED AREA - SQ.FT.	1550	746	913	1009	979	981	948	
	BODY M.L. VOLUME-CU.FT.	2537	1042	1428	1561		1283	2089	

DESIGNATORS

A A3B
B F3B
C F4B
D F101A
E F102A(DELTA DART)
F F105B
G F111A
H

NOTES & SKETCHES

TABLE C.4-2 DATA SUMMARY (TRANSPORT A/C)

CONFIGURATION | BY | DATE

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	2866	11109	5940	11437	27404	25109	2991	34710
2	TAIL GROUP	732	2094	1450	3368	6011	5374	891	5858
3	BODY GROUP	2212	7476	7050	14391	30940	20812	3783	28123
4	INDUCED ENVIR PROTECTION								
5	LANDING, RECOVERY, DOCKING	1396	4771	2372	4939	10635	10444	1081	10515
6	PROPULSION-ASCENT								
7	PROPULSION-CRUISE	5468	19646	10547	20072	22805	24585	5169	29748
8	PROPULSION-AUXILIARY								
9	PRIME POWER		308	183	472	188			568
10	ELECT CONVER & DISTR	623	1543	832	2337	2004	2708	1800	2638
11	HYDRA CONVER & DISTR	207	582	156	668	2679	913	338	1182
12	SURFACE CONTROLS	684	1562	593	1659	1804	2147	939	3794
13	AVIONICS	978	1703	954	3161	2625	2662	1095	3346
14	ENVIRONMENTAL CONTROL	446	2641	1014	2070	2973	1820	608	3046
15	PERSONNEL PROVISIONS	1002	7036	747	4833	3632	3446	1849	3749
16	RANGE SAFETY & ABORT								
17	BALLAST								
18	GROWTH UNCERTAINTY								
19	AUXILIARY	248			62	117		9	138
	SUBTOTAL (DRY WEIGHT)	16862	60471	31838	69469	113817	100002	20553	127415
20	PERSONNEL	400	1800	400	1000	960	860	390	860
21	CARGO	4073	10035	12848	33441	98533	82279	1896	70236
22	ORDNANCE								
23	RESIDUAL FLUIDS	332	1886	922	1090	1693	1703	411	1615
24									
	SUBTOTAL (INERT WEIGHT)	21667	74192	46008	105000	215003	184844	23250	200126
25	RESERVE FLUIDS								
26	IN FLIGHT LOSSES								
27	PROPELLANT-ASCENT								
28	PROPELLANT-CRUISE	3126	28037	14172	50000	60000	94638	17050	117874
29	PROPELLANT-MANEUV ACS								
30									
	TOTAL (GROSS WEIGHT) LB	24793	102229	60180	155000	275003	279482	40300	318000
	BURNOUT WEIGHT-LB								
	DESIGN LANDING WT.-LB	22294		51350	130000	245000	200000	30000	257500
	WING GROSS AREA - SQ.FT.	485	1650	1223	1745	2673	2433	542	3228
	HORIZONTAL TAIL AREA-SQ.FT.	115	347	346	545	801	500	149	483
	VERTICAL TAIL AREA-SQ.FT.	90	154	255	300	640	362	110	416
	BODY WETTED AREA-SQ.FT.	753		2250	3460	6472	4420	1050	5645
	BODY M.L. VOLUME-CU.FT.	795	4042	5190	9060	26052	11550	1710	16000

DESIGNATORS:

VEHICLE

A C-1A
B VC-121B(9 CREW)
C C-123B
D C-130E
E C-133A (4 CREW)
F C-135A (4 CREW)
G C-140 (2 CREW)
H C-141A (4 CREW)

NOTES & SKETCHES:

TABLE C.4-3 DATA SUMMARY (COMMERCIAL A/C AND BOMBERS)

CONFIGURATION | BY | DATE

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP	17986	26463	33554	9119	12156	85750	49574	
2	TAIL GROUP	4282	5360	4751	2411	1227	12361	13288	
3	BODY GROUP	13968	16781	21658	9324	5074	109386	44868	
4	INDUCED ENVIR PROTECTION								
5	LANDING, RECOVERY, DOCKING	7344	9946	10587	3376	3856	37580	17308	
6	PROPULSION-ASCENT								
7	PROPULSION-CRUISE	18812	27570	30258	9274	21124	43914	38781	
8	PROPULSION-AUXILIARY								
9	PRIME POWER				777		967	1616	
10	ELECT CONVER & DISTR	2349	2579	2727	1595	1428	3771	4881	
11	HYDRA CONVER & DISTR	1111	1435	2291	493	485	4194	3234	
12	SURFACE CONTROLS	1816	2507	2057	1086	1357	6543	4866	
13	AVIONICS	2136	2556	2141	1367	4638	5394	4170	
14	ENVIRONMENTAL CONTROL	3084	3621	3225	1574	1014	3828	3515	
15	PERSONNEL PROVISIONS	11389	15253	12579	5703	901	7204	31451	
16	RANGE SAFETY & ABORT								
17	BALLAST								
18	GROWTH UNCERTAINTY								
19	AUXILIARY GEAR	36	52	63	30	95	308		
	SUBTOTAL (DRY WEIGHT)	84313	114123	125891	46129	53355	321200	217552	
20	PERSONNEL	900	1490	1030	600	690	1290	3367	
21	CARGO	24741	35418	36854	19257	10155	126556	112115	
22	ORDNANCE								
23	RESIDUAL FLUIDS	655	780	1281	360	982	1454	1966	
24									
	SUBTOTAL (INERT WEIGHT)	110609	151811	165056	66346	65182	450500	335000	
25	RESERVE FLUIDS								
26	IN FLIGHT LOSSES								
27	PROPELLANT-ASCENT								
28	PROPELLANT-CRUISE	70000	93187	112944	11454	97818	318500	95000	
29	PROPELLANT-MANEUV ACS								
30									
	TOTAL (GROSS WEIGHT)LB	180609	244998	278000	77800	163000	769000	430000	
	BURNOUT WEIGHT-LB								
	DESIGN LANDING WT.-LB	132800	180000	199500	74000	95000	635850	408000	
	WING GROSS AREA -SQ.FT.	2000	2250	2883	925	1542	6200	3550	
	HORIZONTAL TAIL AREA-SQ.FT.	395	426	559	224	0	965	1090	
	VERTICAL TAIL AREA -SQ.FT.	395	295	352	161	160	961	605	
	BODY WETTED AREA-SQ.FT.	3622	3919	4930	2741	1374	15779	9122	
	BODY M.L. VOLUME-CU.FT.	11210	12280			1734	86601	41300	

DESIGNATORS:

VEHICLE

A Convair 880 (6 CREW)
B Convair 990 (10 CREW)
C DC-8-51 (7 CREW)
D DC-9 (4 CREW)
E B-58A (3 CREW)
F C-5A (6 CREW)
G DC-10
H

NOTES & SKETCHES:

TABLE C.4-4 DATA SUMMARY (SPACECRAFT)

CONFIGURATION | BY | DATE

CODE	SYSTEM	A	B	C	D	E	F	G	H
1	WING GROUP		55						
2	TAIL GROUP					2050			
3	BODY GROUP	966	336	6582	2607	145250	47255	13060	
4	INDUCED ENVIR PROTECTION		112			4700	1350		
5	LANDING, RECOVERY, DOCKING	79	80	151	82	3600		345	
6	PROPULSION-ASCENT	1378		3746	1506	124975	20120	4560	
7	PROPULSION-CRUISE								
8	PROPULSION-AUXILIARY	28	68		32			450	
9	PRIME POWER		21		11				
10	ELECT CONVER & DISTR	264	54	359	231	1250	475	350	
11	HYDRA CONVER & DISTR	89		119	113				
12	SURFACE CONTROLS								
13	AVIONICS	554	152	13	16	4675	2615	1680	
14	ENVIRONMENTAL CONTROL		20	128	15				
15	PERSONNEL PROVISIONS								
16	RANGE SAFETY & ABORT			91	71	500	185	55	
17	BALLAST		58						
18	GROWTH UNCERTAINTY								
19									
	SUBTOTAL (DRY WEIGHT)	3358	956	11189	4684	287000	72000	20500	
20	PERSONNEL								
21	CARGO	132	16						
22	ORDNANCE								
23	RESIDUAL FLUIDS	491	6	1396	592	38544	8110	850	
24									
	SUBTOTAL (INERT WEIGHT)	3981	978	12585	5276	325544	80110	21350	
25	RESERVE FLUIDS					13100	1695	1345	
26	IN FLIGHT LOSSES	3483		1631	1013	24959	4550	4470	
27	PROPELLANT-ASCENT	30040		244960	65591	424524	930000	230000	
28	PROPELLANT-CRUISE								
29	PROPELLANT-MANEUV ACS		80					40	
30				①	②				
	TOTAL (GROSS WEIGHT)LB	37504	1058	259176	71880	460884	1016355	257205	
	BURNOUT WEIGHT-LB								
	DESIGN LANDING WT.-LB								
	WING GROSS AREA-SQ.FT.								
	HORIZONTAL TAIL AREA-SQ.FT.								
	VERTICAL TAIL AREA-SQ.FT.							③	
	BODY WETTED AREA-SQ.FT.	1100	47	1749	804	14359	10176	3488	
	BODY M.L. VOLUME-CU.FT.	2360	13	3979	1617	104346	69720	14990	

DESIGNATORS

VEHICLE
A CENTAUR
B ASSET
C TITAN IIIC CORE (STAGE I)
D TITAN IIIC CORE (STAGE II)
E SATURN SIC
F SATURN SII
G SATURN SIVB
H

NOTES & SKETCHES:

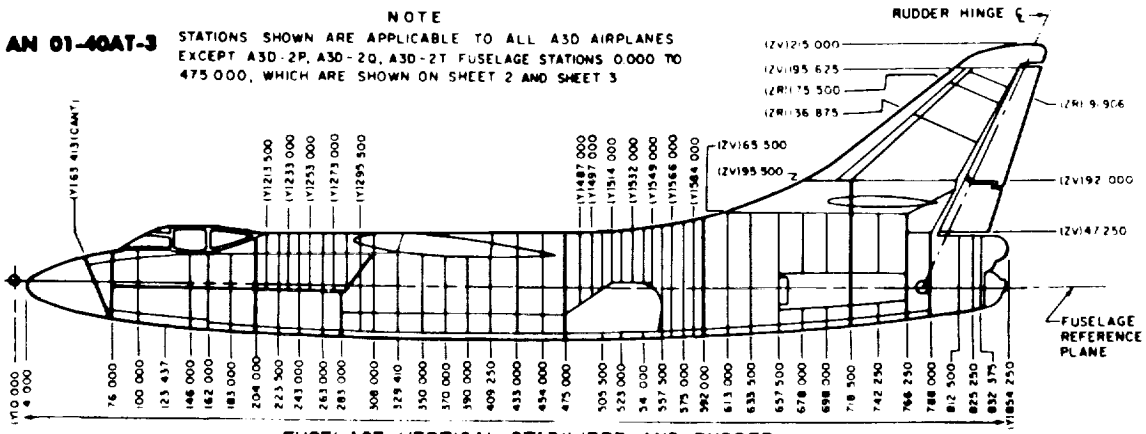
① DOES NOT INCLUDE 866 LB TRANSPORTATION SECTION
② DOES NOT INCLUDE 503 LB OF FWD. SECTION
③ IF INTERSTAGE TRANSITION SECTION (4000 LB) IS INCLUDED WETTED AREA INCREASES TO 5584 SQ.FT. AND VOLUME INCREASED TO 25590 CU.FT.

A-3B

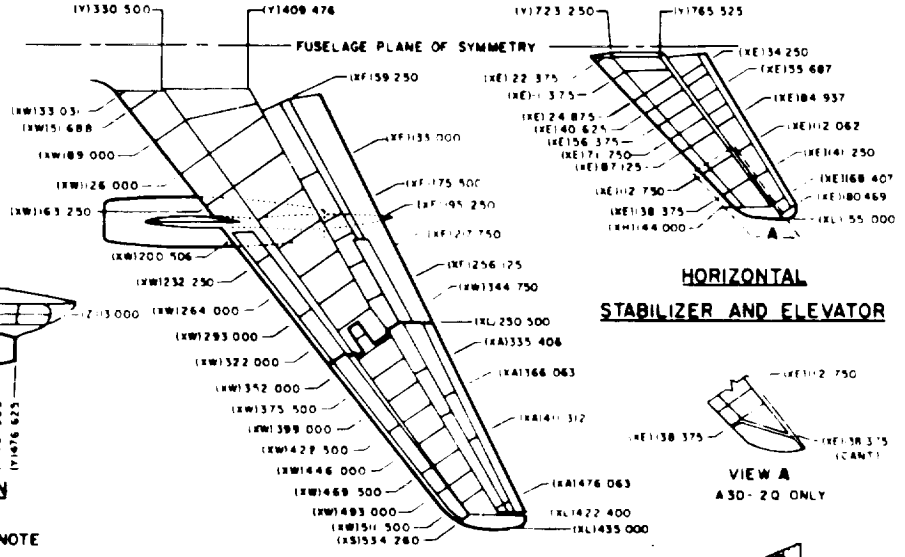
AN 01-40AT-3

NOTE

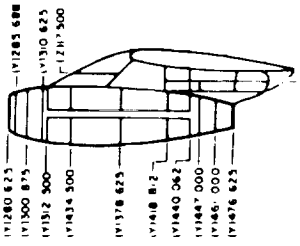
STATIONS SHOWN ARE APPLICABLE TO ALL A3D AIRPLANES EXCEPT A3D-2P, A3D-2Q, A3D-2T FUSELAGE STATIONS 0.000 TO 475.000, WHICH ARE SHOWN ON SHEET 2 AND SHEET 3



FUSELAGE, VERTICAL STABILIZER AND RUDDER



HORIZONTAL STABILIZER AND ELEVATOR



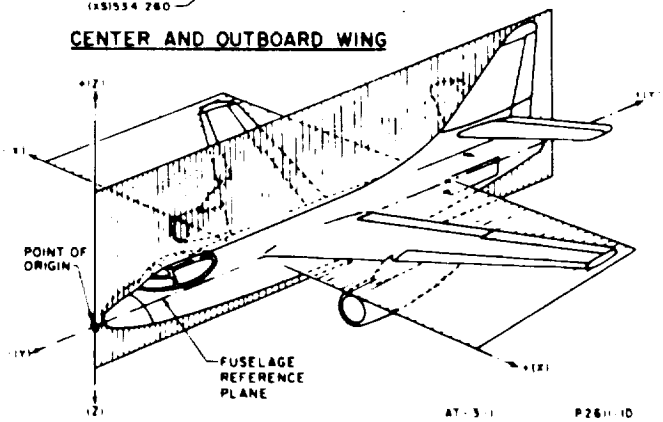
NACELLE AND PYLON

VIEW A
A3D-2Q ONLY

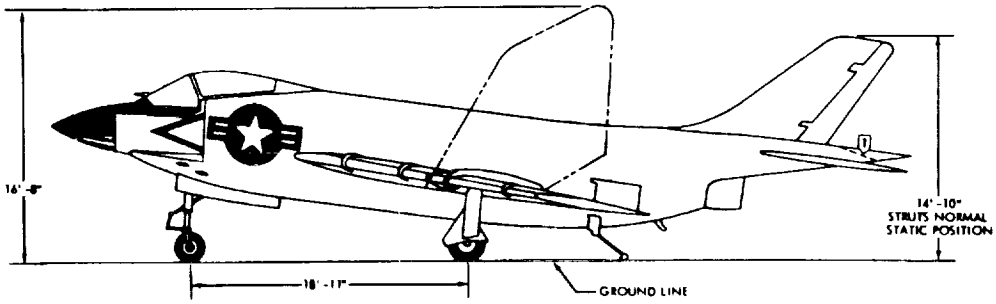
NOTE

Y (FUSELAGE) STATIONS ARE PERPENDICULAR TO FUSELAGE REFERENCE PLANE
Z AND ZV (VERTICAL STABILIZER) STATIONS ARE PARALLEL TO FUSELAGE REFERENCE PLANE
X (WING) STATIONS # ARE PARALLEL TO FUSELAGE PLANE OF SYMMETRY
XL (LATERAL) STATIONS ARE PARALLEL TO X STATIONS
XW (WING) STATIONS # ARE PERPENDICULAR TO FRONT SPAR OF WING
XS (SLAT) STATIONS ARE PERPENDICULAR TO SLAT HINGE LINE
XA (AILERON) STATIONS ARE PERPENDICULAR TO AILERON HINGE LINE
XF (FLAP) STATIONS ARE PERPENDICULAR TO FLAP HINGE LINE
XE (ELEVATOR) STATIONS ARE PERPENDICULAR TO ELEVATOR HINGE LINE
XH (HORIZONTAL STABILIZER) STATIONS ARE PARALLEL TO A TRACE OF FUSELAGE PLANE OF SYMMETRY
ZR (RUDDER) STATIONS ARE PERPENDICULAR TO RUDDER HINGE LINE
MORE THAN ONE TYPE OF WING STATION HAS BEEN INDICATED (SEE AXIS SYSTEM DIAGRAM AND VARIOUS VIEWS OF AIRPLANE - THIS ILLUSTRATION)

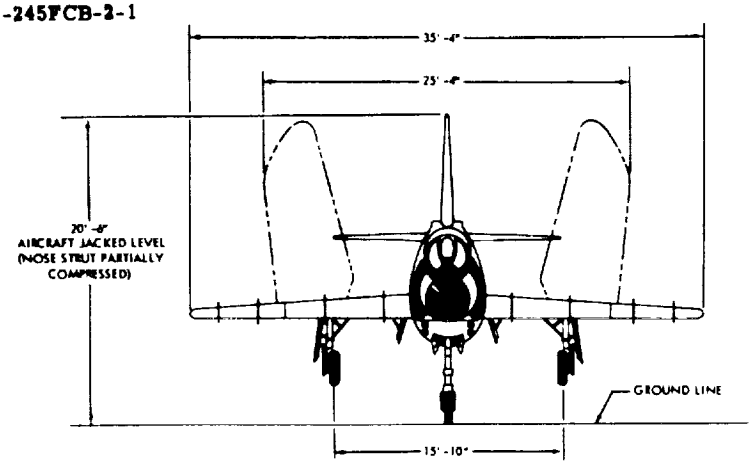
CENTER AND OUTBOARD WING



F-3B

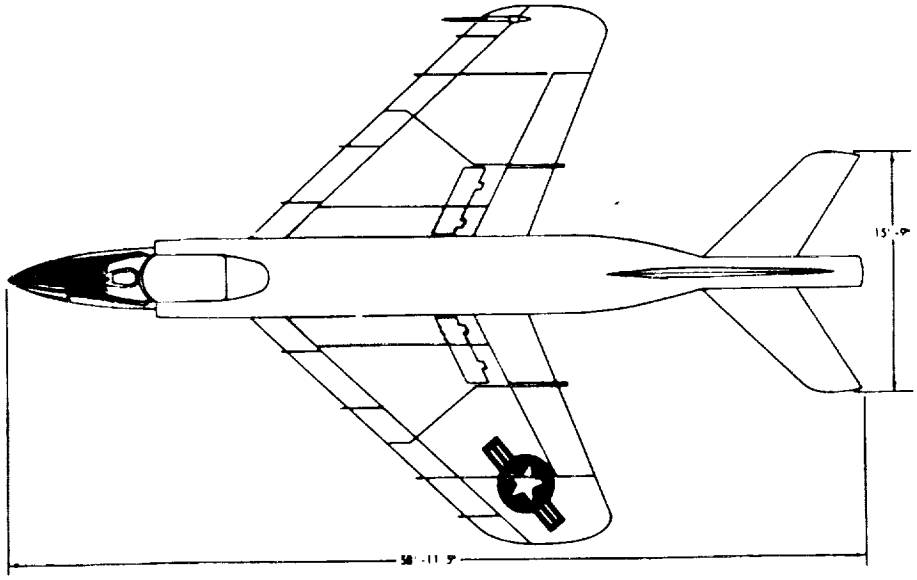


NAVAER 01-245FCB-2-1



NOTE

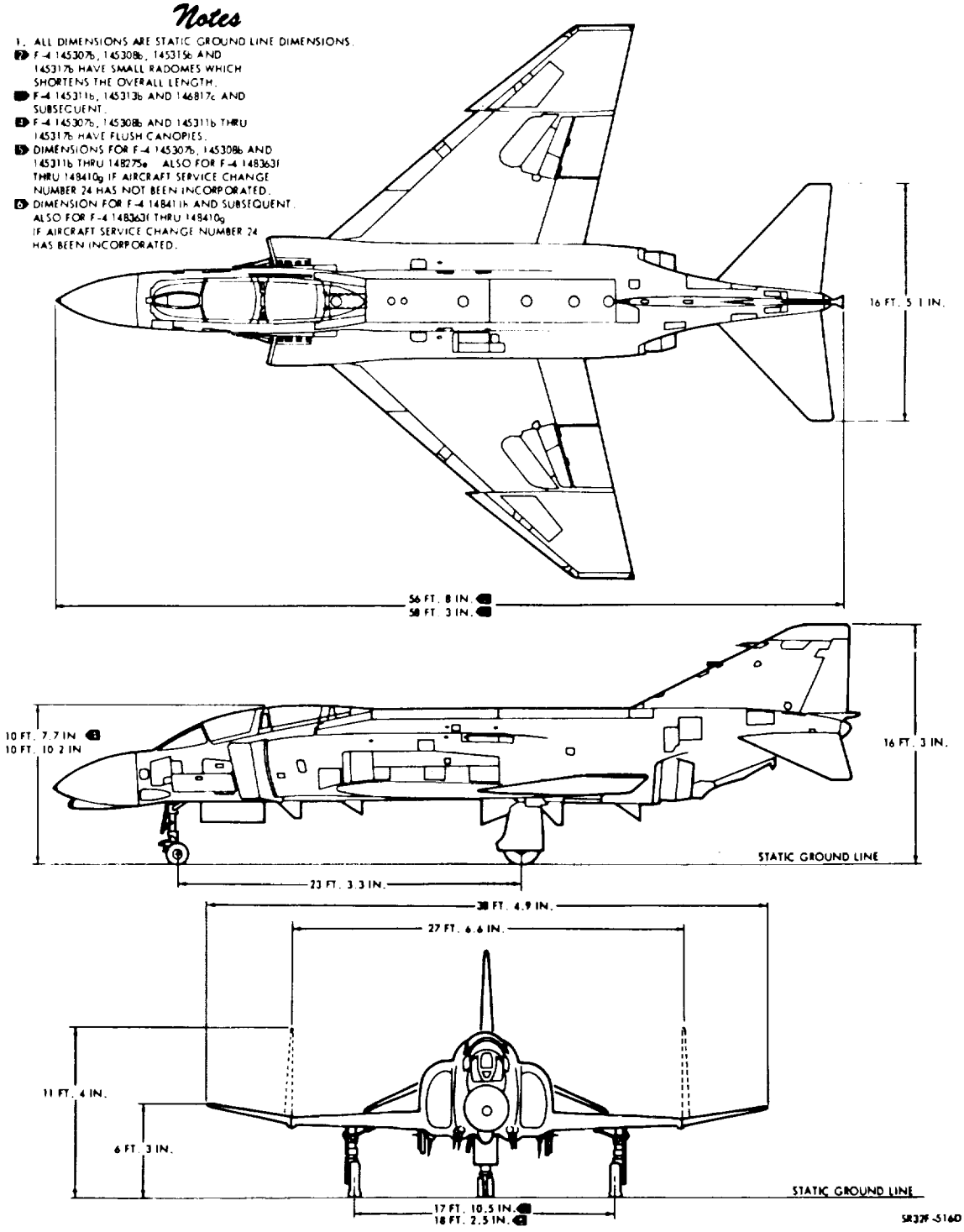
[D] EFFECTIVE BLOCK L AND UP "BEAVER TAIL" HAS BEEN SHORTENED BY APPROXIMATELY TWO FEET.



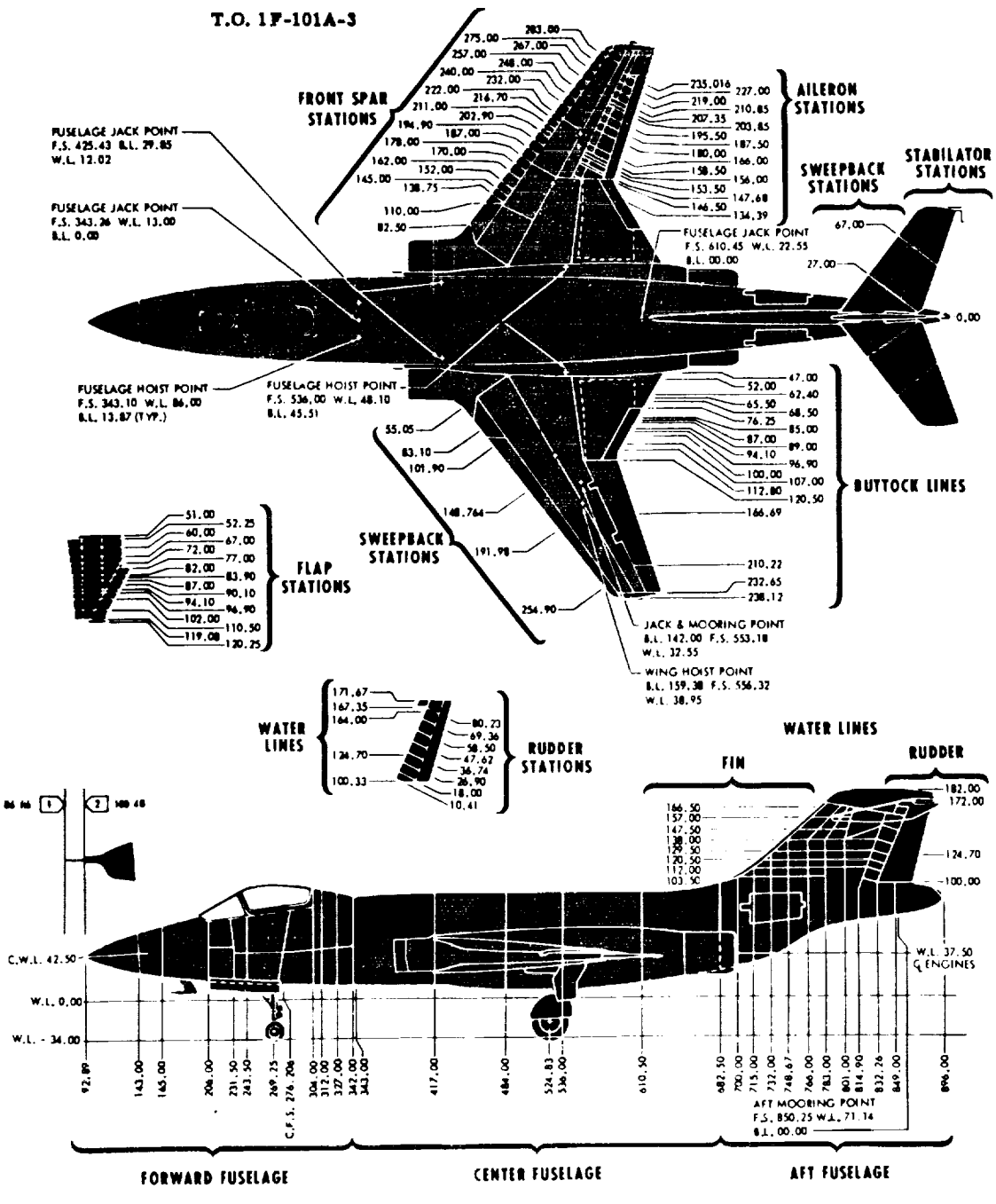
F-4A
F-4B

Notes

1. ALL DIMENSIONS ARE STATIC GROUND LINE DIMENSIONS.
2. F-4 145307b, 145308b, 145315b AND 145317b HAVE SMALL RADOMES WHICH SHORTENS THE OVERALL LENGTH.
3. F-4 145311b, 145313b AND 146817c AND SUBSEQUENT.
4. F-4 145307b, 145308b AND 145311b THRU 145317b HAVE FLUSH CANOPIES.
5. DIMENSIONS FOR F-4 145307b, 145308b AND 145311b THRU 148275e. ALSO FOR F-4 148363f THRU 148410g IF AIRCRAFT SERVICE CHANGE NUMBER 24 HAS NOT BEEN INCORPORATED.
6. DIMENSION FOR F-4 148411h AND SUBSEQUENT. ALSO FOR F-4 148363f THRU 148410g IF AIRCRAFT SERVICE CHANGE NUMBER 24 HAS BEEN INCORPORATED.



F-101A


T.O. 1F-101A-3
FRONT SPAR STATIONS
AILERON STATIONS
SWEEPBACK STATIONS
STABILATOR STATIONS
FUSELAGE JACK POINT F.S. 425.43 B.L. 29.85 W.L. 12.02
FUSELAGE JACK POINT F.S. 343.26 W.L. 13.00 B.L. 0.00
FUSELAGE JACK POINT F.S. 610.45 W.L. 22.55 B.L. 00.00
FUSELAGE HOIST POINT F.S. 343.10 W.L. 86.00 B.L. 13.87 (TYP.)
FUSELAGE HOIST POINT F.S. 536.00 W.L. 48.10 B.L. 45.51
BUTTOCK LINES
FLAP STATIONS
SWEEPBACK STATIONS
JACK & MOORING POINT B.L. 142.00 F.S. 553.18 W.L. 32.55
WING HOIST POINT B.L. 159.38 F.S. 556.32 W.L. 38.95
WATER LINES
RUDDER STATIONS
FIN
RUDDER
C.W.L. 42.50
W.L. 0.00
W.L. - 34.00
W.L. 37.50 ℄ ENGINES
AFT MOORING POINT F.S. 850.25 W.L. 71.14 B.L. 00.00
FORWARD FUSELAGE
CENTER FUSELAGE
AFT FUSELAGE

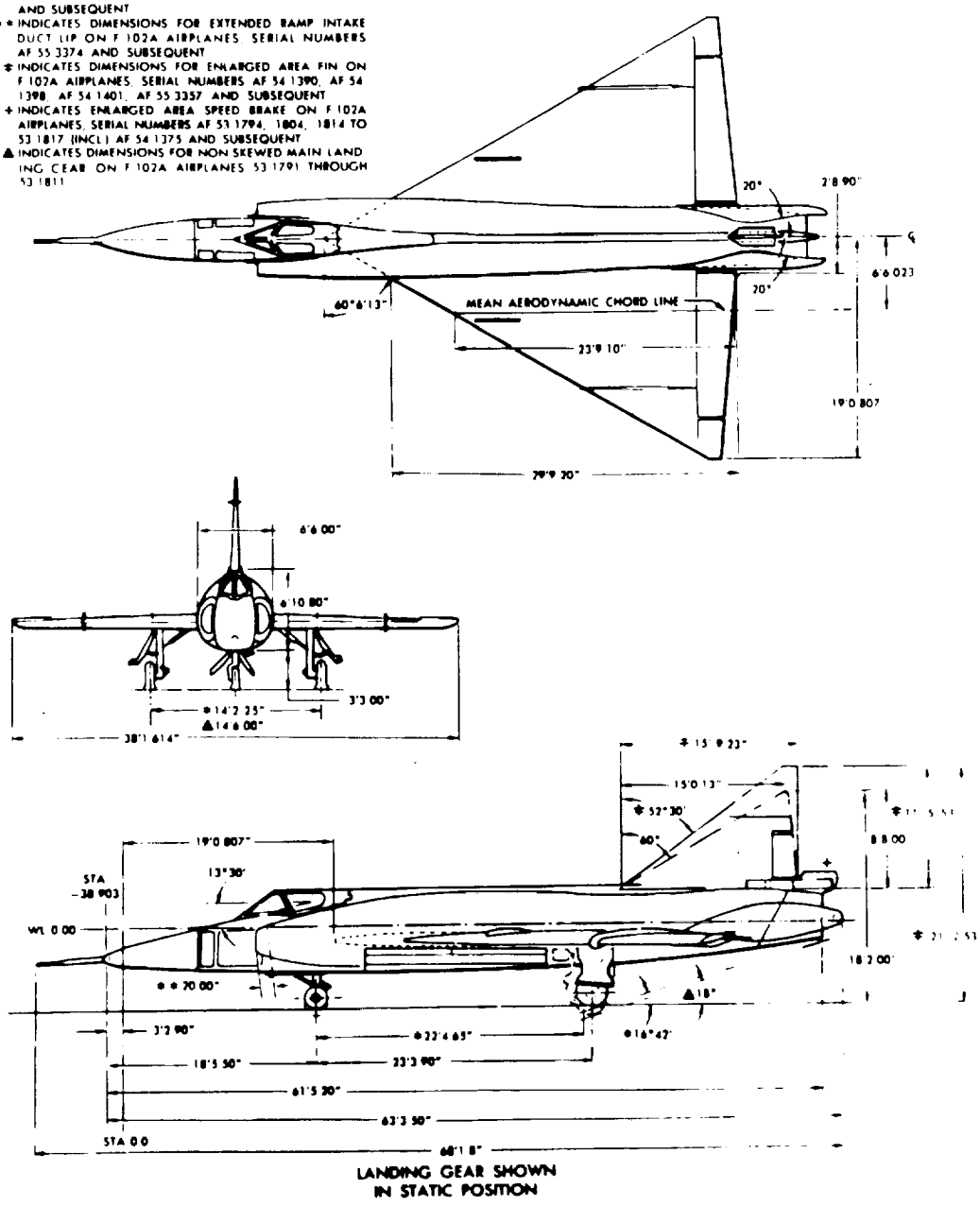
(1) TIP OF PITOT AFTER T.O. 1F-101-1112.

(2) LEADING EDGE OF NOSE CONE AFTER T.O. 1F-101-1112.

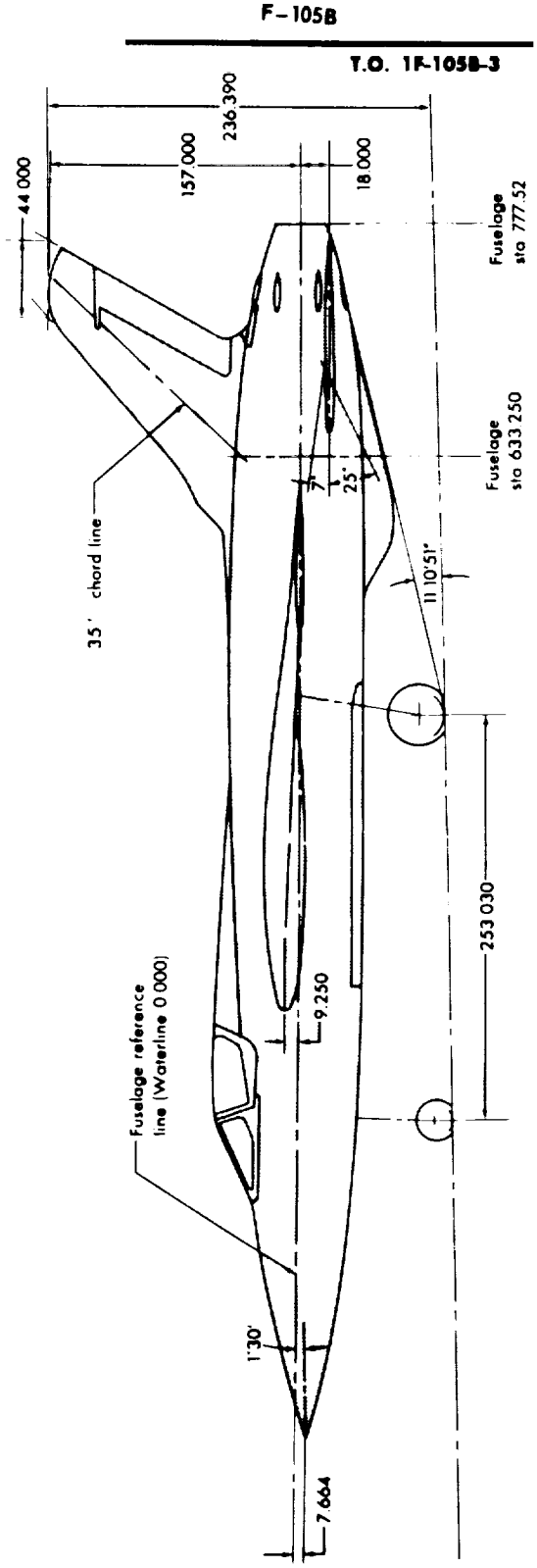
F-102A

T.O. 1F-102A-3-3

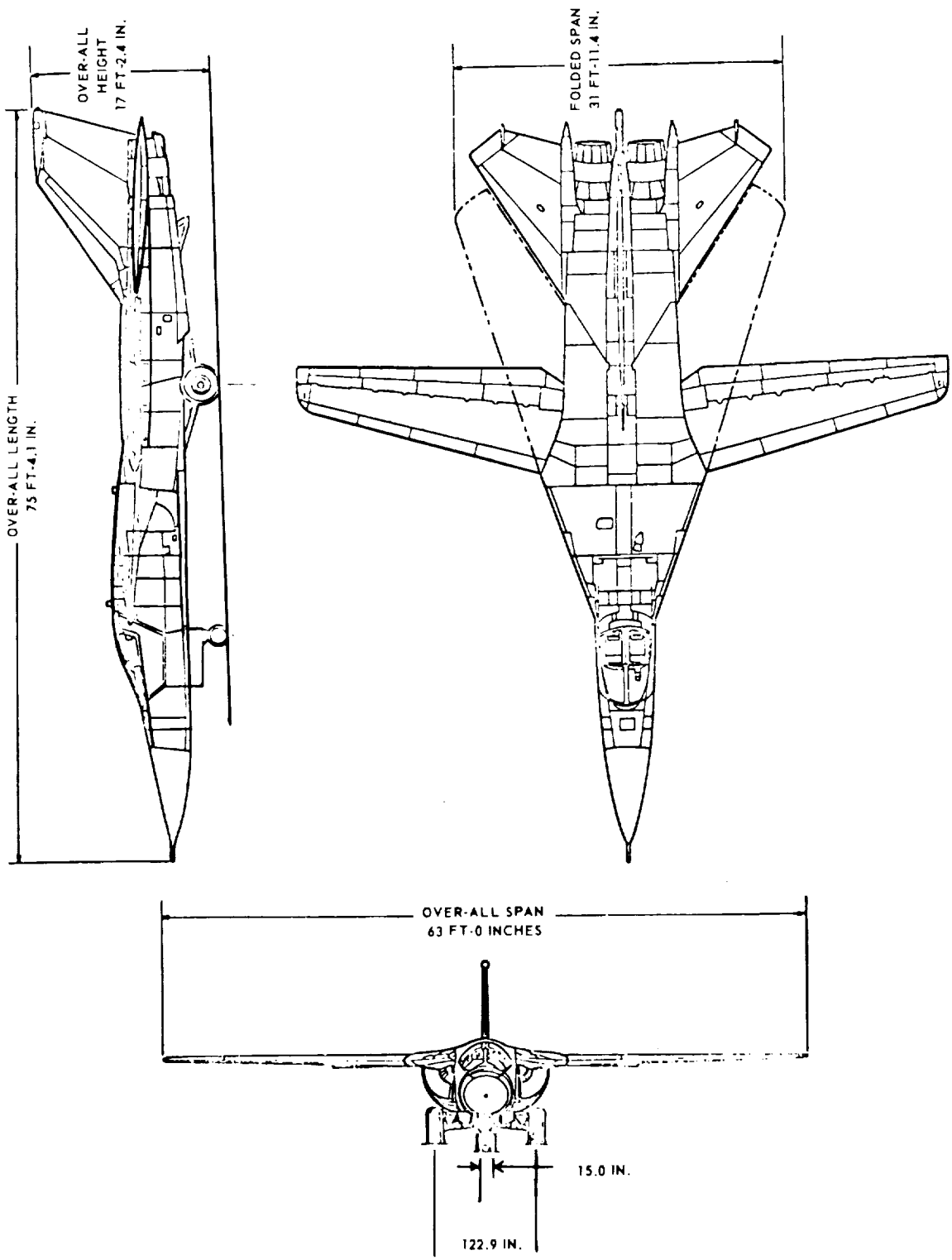
NOTES
* INDICATES DIMENSIONS FOR SKEWED MAIN LANDING GEAR ON F 102A AIRPLANES SERIAL NUMBERS AF 53 1812 AND SUBSEQUENT
* * INDICATES DIMENSIONS FOR EXTENDED RAMP INTAKE DUCT LIP ON F 102A AIRPLANES SERIAL NUMBERS AF 55 3374 AND SUBSEQUENT
* INDICATES DIMENSIONS FOR ENLARGED AREA FIN ON F 102A AIRPLANES SERIAL NUMBERS AF 54 1390, AF 54 1398, AF 54 1401, AF 55 3357 AND SUBSEQUENT
+ INDICATES ENLARGED AREA SPEED BRAKE ON F 102A AIRPLANES SERIAL NUMBERS AF 53 1794, 1804, 1814 TO 53 1817 (INCL) AF 54 1375 AND SUBSEQUENT
▲ INDICATES DIMENSIONS FOR NON SKEWED MAIN LANDING GEAR ON F 102A AIRPLANES 53 1791 THROUGH 53 1811



LANDING GEAR SHOWN
IN STATIC POSITION

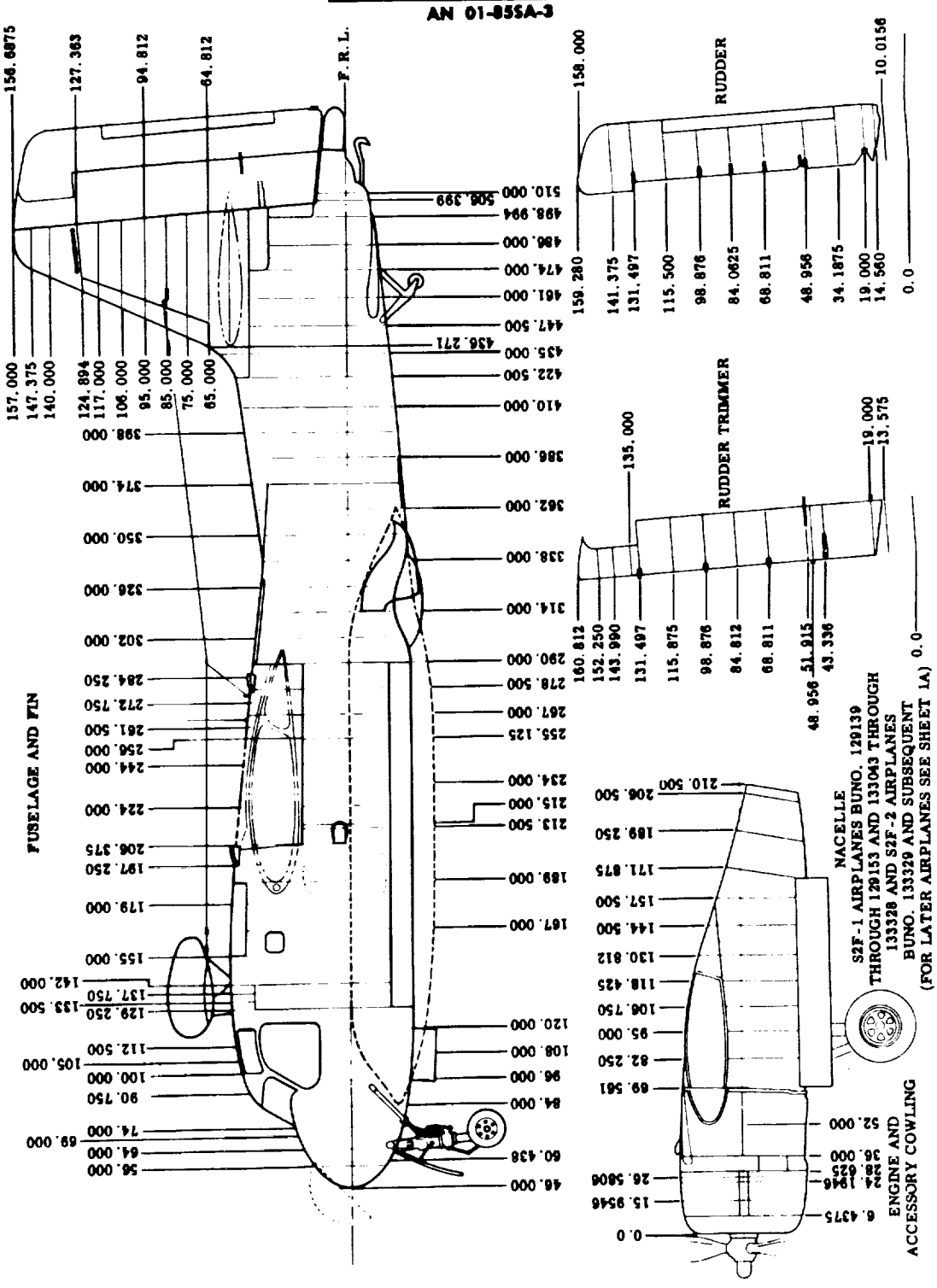

F-105B
T.O. 1F-105B-3
236.390
157.000
18.000
44.000
Fuselage sta 777.52
Fuselage sta 633.250
7°
2.5°
11°10'51"
35° chord line
253.030
9.250
Fuselage reference line (Waterline 0.000)
1°30'
7.664

F-111A

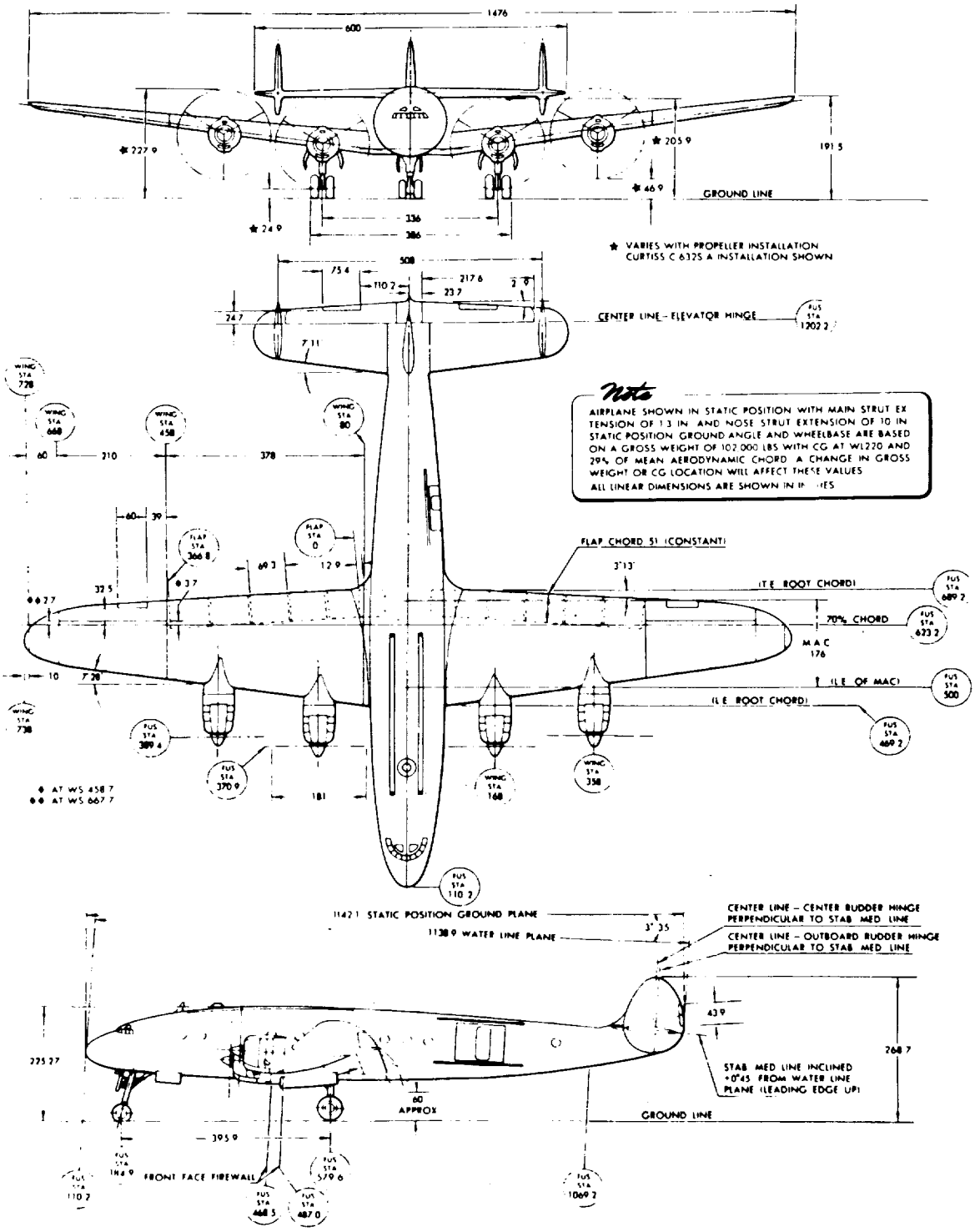

OVER-ALL HEIGHT 17 FT-2.4 IN.
OVER-ALL LENGTH 75 FT-4.1 IN.
FOLDED SPAN 31 FT-11.4 IN.
OVER-ALL SPAN 63 FT-0 INCHES
15.0 IN.
122.9 IN.

C-1A

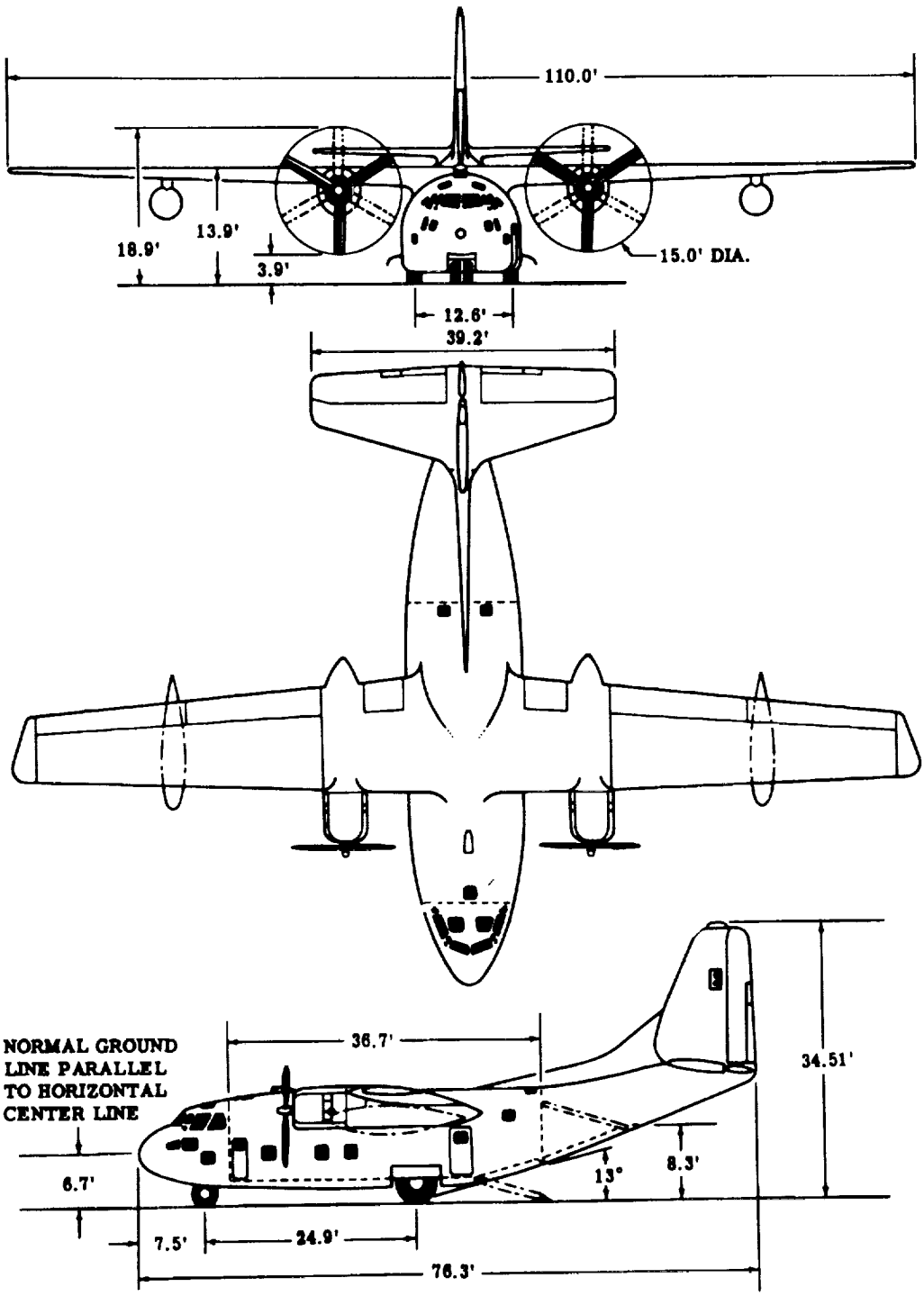
AN 01-85SA-3


F.R.L.
FUSELAGE AND FIN
RUDDER
RUDDER TRIMMER
NACELLE
S2F-1 AIRPLANES BUNO. 129139 THROUGH 129153 AND 133043 THROUGH 133328 AND S2F-2 AIRPLANES BUNO. 133329 AND SUBSEQUENT (FOR LATER AIRPLANES SEE SHEET 1A)
ENGINE AND ACCESSORY COWLING

VC-121B

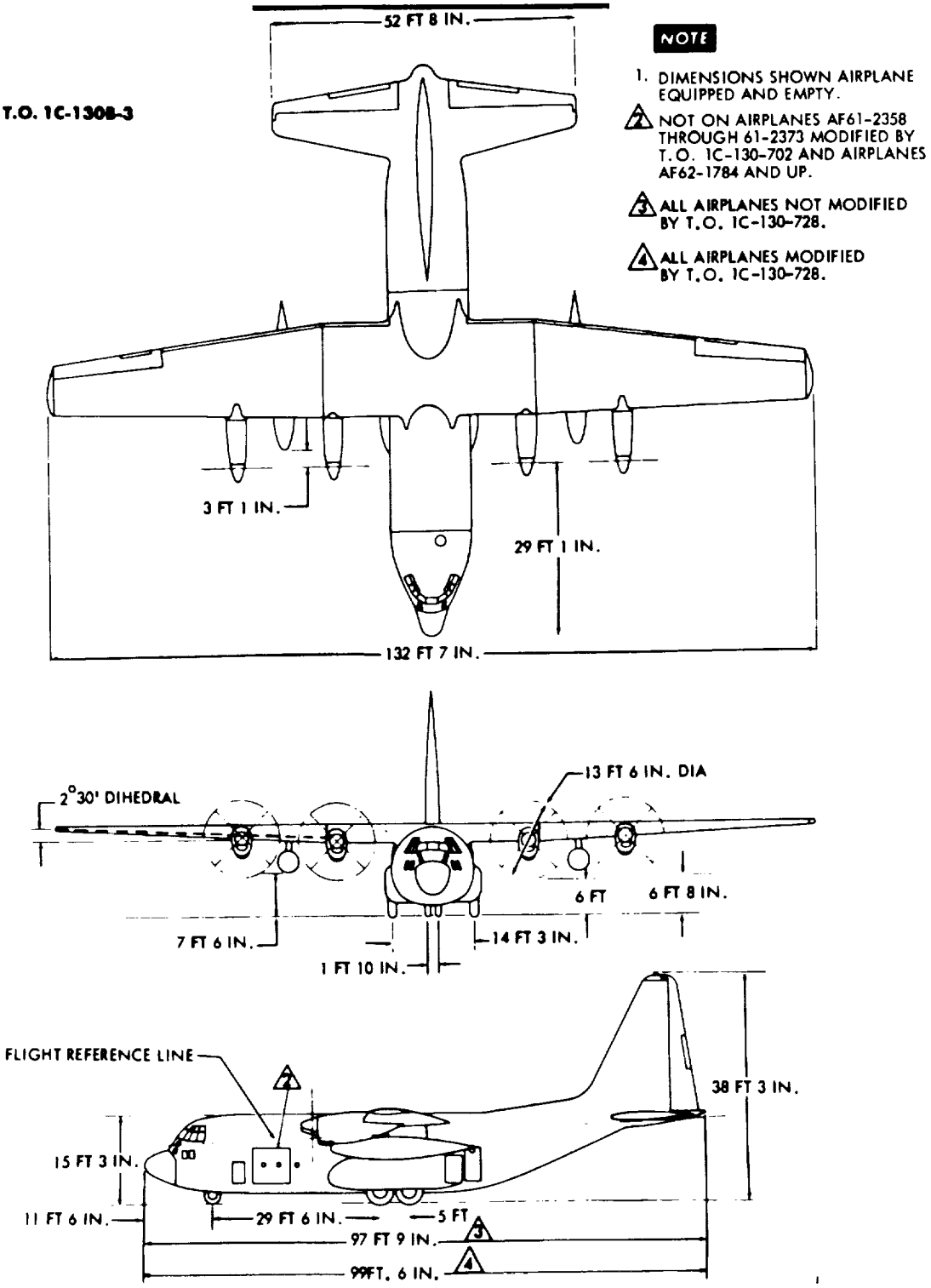

1476
600
★ 227 9
★ 205 9
191 5
★ 46 9
GROUND LINE
★ 24 9
336
386
★ VARIES WITH PROPELLER INSTALLATION
CURTISS C 632S A INSTALLATION SHOWN
508
75 4
110 2
217 6
23 7
2 6
24 7
7 11
CENTER LINE – ELEVATOR HINGE
FUS STA 1202 2
Note
AIRPLANE SHOWN IN STATIC POSITION WITH MAIN STRUT EX TENSION OF 13 IN AND NOSE STRUT EXTENSION OF 10 IN STATIC POSITION GROUND ANGLE AND WHEELBASE ARE BASED ON A GROSS WEIGHT OF 102 000 LBS WITH CG AT WL220 AND 29% OF MEAN AERODYNAMIC CHORD A CHANGE IN GROSS WEIGHT OR CG LOCATION WILL AFFECT THESE VALUES
ALL LINEAR DIMENSIONS ARE SHOWN IN IN ES
WING STA 728
WING STA 668
WING STA 458
WING STA 80
60
210
378
60
39
FLAP STA 366 8
FLAP STA 0
69 3
12 9
FLAP CHORD 51 (CONSTANT)
3°13'
32 5
0 37
0 27
(T E ROOT CHORD)
FUS STA 689 2
70% CHORD
FUS STA 623 2
M A C 176
10
7 28
(L E OF MAC)
FUS STA 500
(L E ROOT CHORD)
FUS STA 469 2
WING STA 738
FUS STA 389 4
FUS STA 370 9
181
WING STA 168
WING STA 358
0 AT WS 458 7
00 AT WS 667 7
FUS STA 110 2
11421 STATIC POSITION GROUND PLANE
11389 WATER LINE PLANE
3° 35
CENTER LINE – CENTER RUDDER HINGE PERPENDICULAR TO STAB MED LINE
CENTER LINE – OUTBOARD RUDDER HINGE PERPENDICULAR TO STAB MED LINE
43 9
268 7
225 27
STAB MED LINE INCLINED +0°45 FROM WATER LINE PLANE (LEADING EDGE UP)
60 APPROX
GROUND LINE
395 9
FUS STA 184 9
FRONT FACE FIREWALL
FUS STA 379 6
FUS STA 110 2
FUS STA 468 5
FUS STA 487 0
FUS STA 1069 2

C-123B


110.0'
18.9'
13.9'
3.9'
15.0' DIA.
12.6'
39.2'
NORMAL GROUND
LINE PARALLEL
TO HORIZONTAL
CENTER LINE
36.7'
34.51'
6.7'
13°
8.3'
7.5'
24.9'
76.3'

C-130E

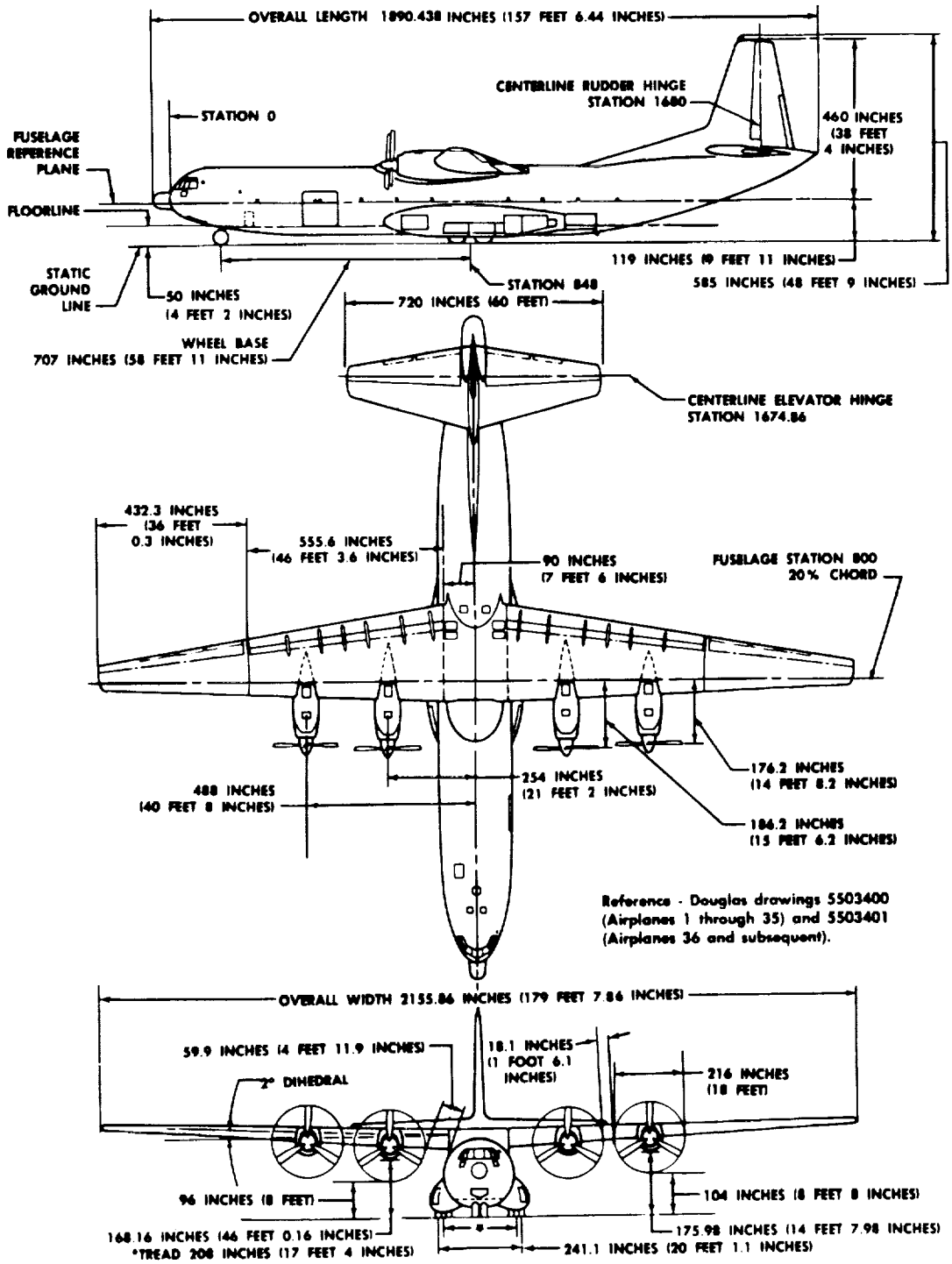
T.O. 1C-1308-3



NOTE

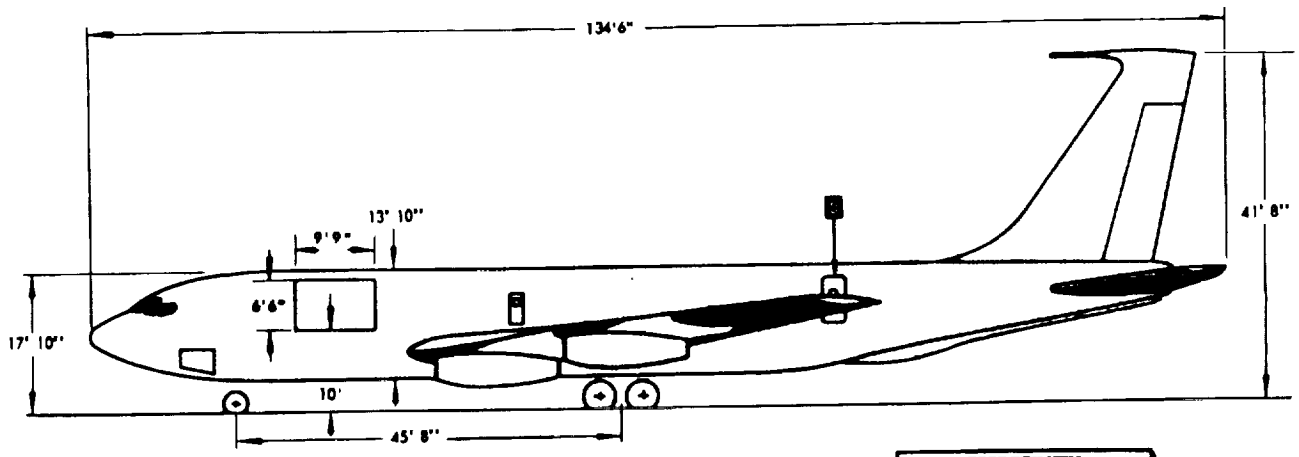
1. DIMENSIONS SHOWN AIRPLANE EQUIPPED AND EMPTY.
2. NOT ON AIRPLANES AF61-2358 THROUGH 61-2373 MODIFIED BY T.O. 1C-130-702 AND AIRPLANES AF62-1784 AND UP.
3. ALL AIRPLANES NOT MODIFIED BY T.O. 1C-130-728.
4. ALL AIRPLANES MODIFIED BY T.O. 1C-130-728.

C-133A

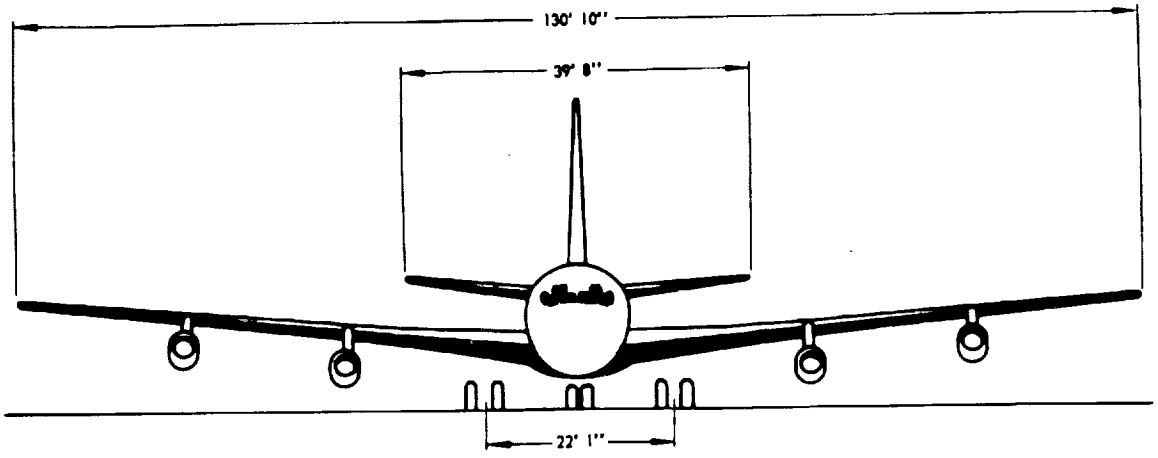

OVERALL LENGTH 1890.438 INCHES (157 FEET 6.44 INCHES)
CENTERLINE RUDDER HINGE STATION 1680
STATION 0
460 INCHES (38 FEET 4 INCHES)
FUSELAGE REFERENCE PLANE
FLOORLINE
119 INCHES (9 FEET 11 INCHES)
585 INCHES (48 FEET 9 INCHES)
STATIC GROUND LINE
50 INCHES (4 FEET 2 INCHES)
STATION 848
720 INCHES (60 FEET)
WHEEL BASE 707 INCHES (58 FEET 11 INCHES)
CENTERLINE ELEVATOR HINGE STATION 1674.86
432.3 INCHES (36 FEET 0.3 INCHES)
555.6 INCHES (46 FEET 3.6 INCHES)
90 INCHES (7 FEET 6 INCHES)
FUSELAGE STATION 800 20% CHORD
176.2 INCHES (14 FEET 8.2 INCHES)
254 INCHES (21 FEET 2 INCHES)
488 INCHES (40 FEET 8 INCHES)
186.2 INCHES (15 FEET 6.2 INCHES)
Reference - Douglas drawings 5503400 (Airplanes 1 through 35) and 5503401 (Airplanes 36 and subsequent).
OVERALL WIDTH 2155.86 INCHES (179 FEET 7.86 INCHES)
59.9 INCHES (4 FEET 11.9 INCHES)
2° DIHEDRAL
18.1 INCHES (1 FOOT 6.1 INCHES)
216 INCHES (18 FEET)
96 INCHES (8 FEET)
104 INCHES (8 FEET 8 INCHES)
168.16 INCHES (46 FEET 0.16 INCHES)
*TREAD 208 INCHES (17 FEET 4 INCHES)
175.98 INCHES (14 FEET 7.98 INCHES)
241.1 INCHES (20 FEET 1.1 INCHES)

C-135A

T.O. 1C-135(K)A-3-1

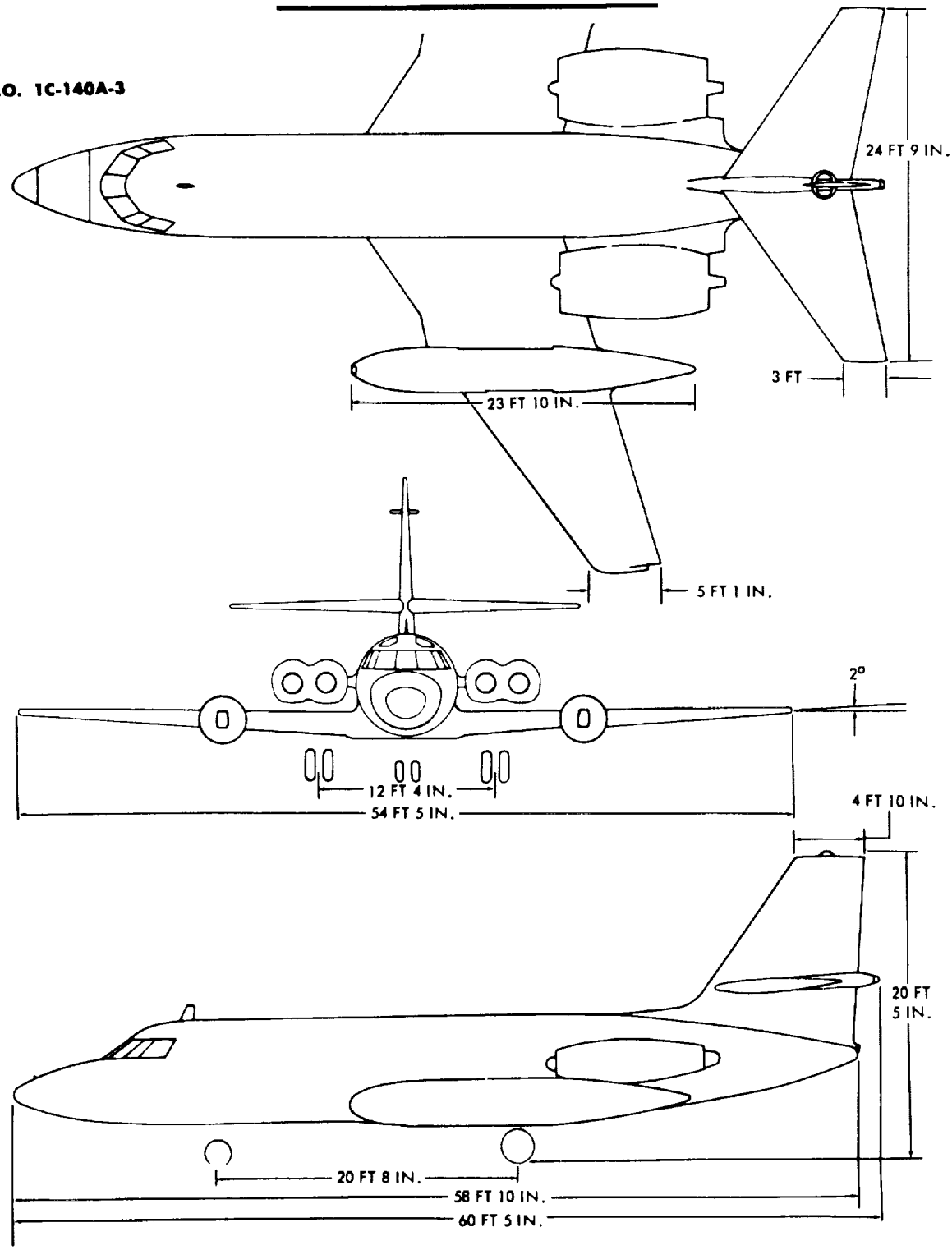


EFFECTIVITY
C-135A AND RC-135A



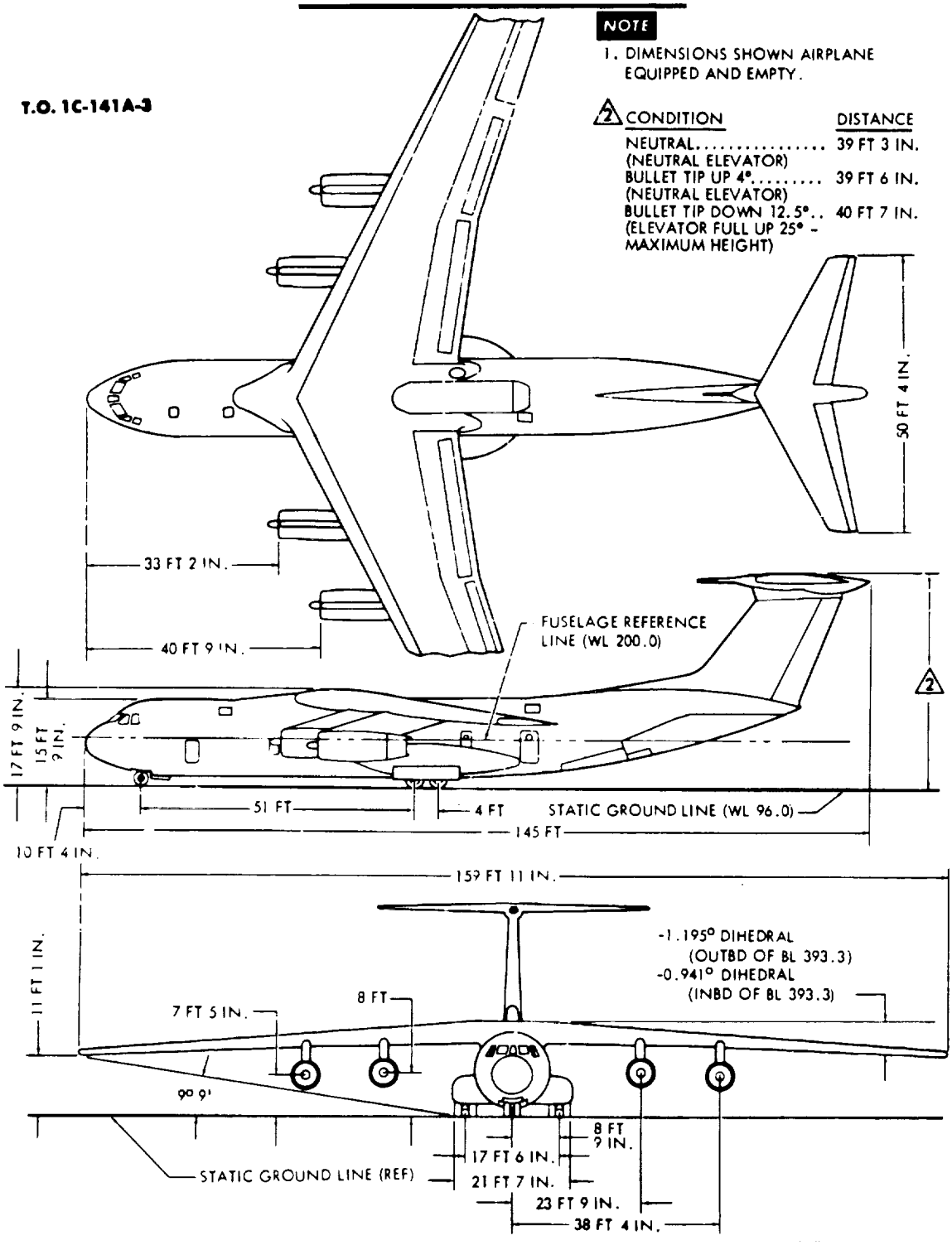
C-140

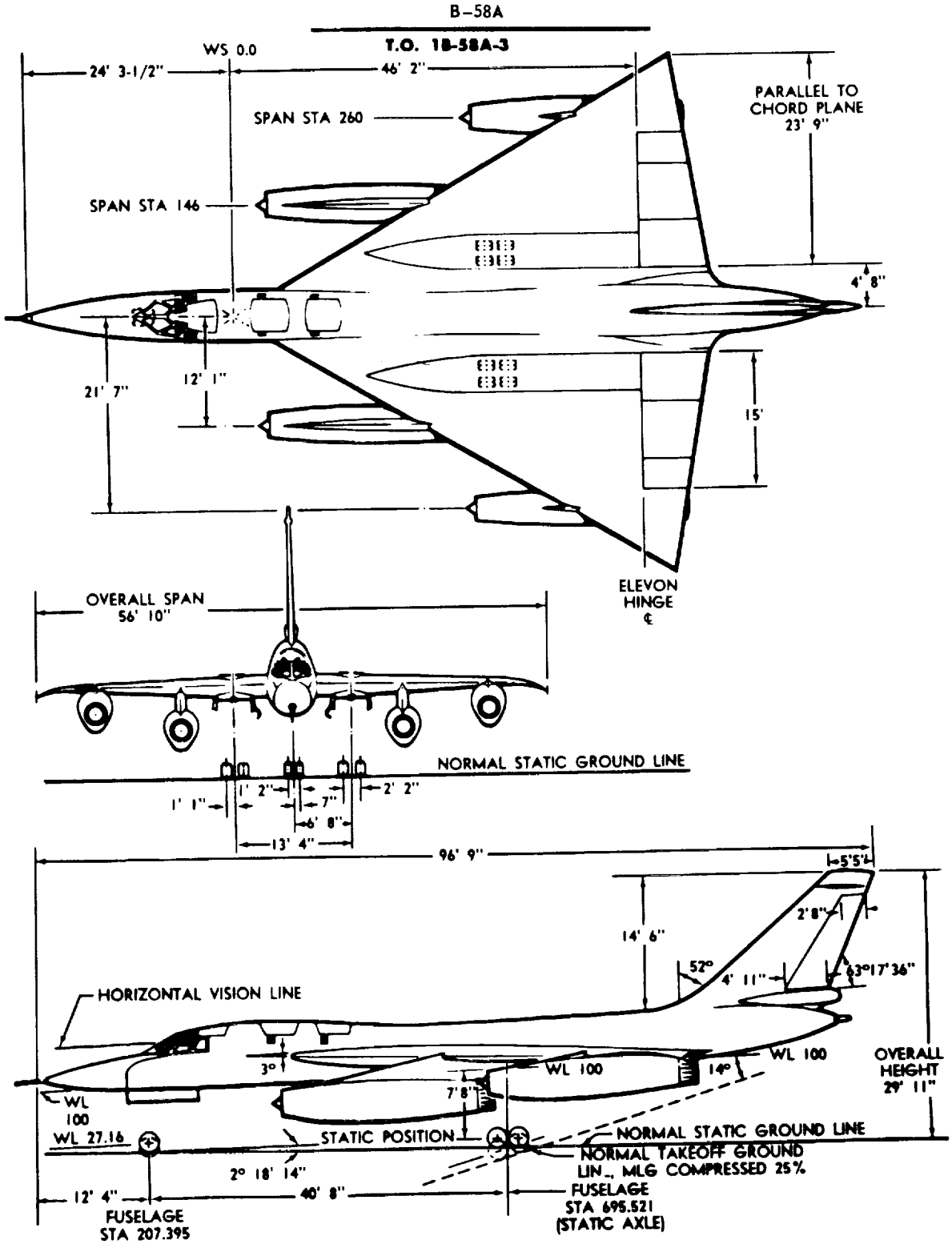
T.O. 1C-140A-3



C-141A

T.O. 1C-141A-3




B-58A
T.O. 1B-58A-3
WS 0.0
24' 3-1/2"
46' 2"
SPAN STA 260
SPAN STA 146
PARALLEL TO CHORD PLANE 23' 9"
4' 8"
21' 7"
12' 1"
15'
ELEVON HINGE ℄
OVERALL SPAN 56' 10"
NORMAL STATIC GROUND LINE
1' 1"
1' 2"
7"
6' 8"
2' 2"
13' 4"
96' 9"
5'5'4
14' 6"
2'8"
52°
4' 11"
63°17'36"
HORIZONTAL VISION LINE
3°
WL 100
14°
WL 100
OVERALL HEIGHT 29' 11"
7'8"
WL 100
WL 27.16
STATIC POSITION
NORMAL STATIC GROUND LINE
NORMAL TAKEOFF GROUND LIN., MLG COMPRESSED 25%
2° 18' 14"
12' 4"
40' 8"
FUSELAGE STA 207.395
FUSELAGE STA 695.521 (STATIC AXLE)

APPENDIX D

DESIGN MASS PROPERTIES

Design Mass Properties for the delta orbiter, canard booster and combined launch configuration are presented in Tables D-1 thru D-5 of this appendix. This data is based on the vehicle configurations and weights presented in the 15 March Detailed Mass Properties Report (MP-8A) and shown in Figures D-1 and D-2.

The specific ground rules used in setting up the design mass properties are described in Table D-6. Three different missions have been considered, i.e.,

- o 40K polar (no orbiter ABES)
- o 25K, 55 degree resupply (with orbiter ABES)
- o 65K, easterly (no orbiter ABES)

The missions without orbiter ABES (airbreathing engine system) carry a scar weight for the ABES, i.e., the vehicle is designed for ABES but the engine and engine systems are removed.

Orbiter design weights are based on the largest value obtained at each mission point based on nominal mission histories for the above three missions. Maximum and minimum design c.g.'s are based on specific off-nominal variations of the three missions as described in Tables D-6.1 thru D-6.3. In defining the various c.g. limits 7 different combinations of payload, expendables, and growth/uncertainty were considered. These are described in Table D-7. The design c.g. limits shown in Tables D-1 thru D-5 represent the maximum and minimum values obtained at each mission point from consideration of all seven payload/expendables configurations. As a result, the values shown in Tables D-1 thru D-5 are uncorrelated, i.e., do not occur simultaneously. For example, the fwd x c.g. limit at entry in Table D-1 is based on Configuration E whereas the UP z c.g. limit is based on Configuration G. Correlated values for each payload/expendable

configuration are presented in Table D-8 for the orbiter and in Table D-9 for the combined orbiter and booster. "Configuration" as used above indicates a different internal arrangement of payload, expendables, and growth/uncertainty, not a different external shape. The following orbiter payload/expendables configurations were used:

Configuration A - Nominal Easterly Mission

Configuration B - Nominal Resupply Mission

Configuration C - No Cargo

Configuration D - Most Aft

Configuration E - Most Left, Most Fwd

Configuration F - Most Right

Configuration G - Most Up

Booster design mass properties are all based on a nominal mission for the booster presented in the 15 March Status Report (MP-8A).

Note: Design Mass Properties are based on Orbiter Drawing No. 255BJ00050 Rev. F.

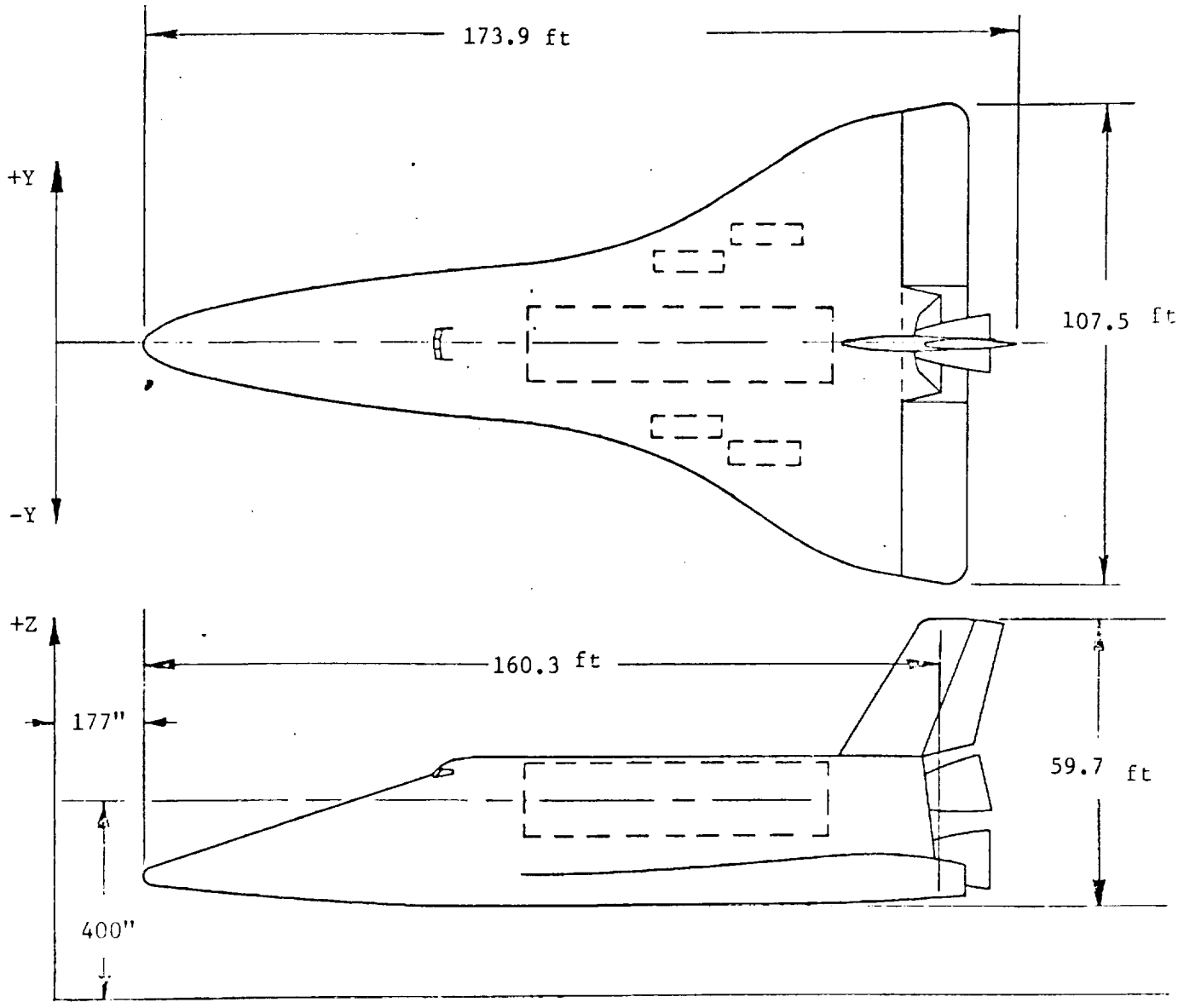


FIGURE D-1 ORBITER CONFIGURATION/COORDINATE AXES

Table D-1 - Design Mass Properties - Delta Orbiter

Weight and C.G.

Mission Phase	Weight-LB	*	X C.G.-In (Fwd / Aft)	*	Y C.G.-In (Left / Right)	*	Z C.G.-In (UP / Down)	*
Booster Separation	859383	A	1052 (45.5)	C	-.5	E	255	G
			1081 (47.0)	D	.5	F	242	C
Injection	334117	A	1456 (66.5)	E	-1.2	E	296	G
			1509 (69.3)	C	1.2	F	269	C
On Orbit	320543	A	1470 (67.2)	E	-1.3	E	301.	G
			1510 (69.3)	C	1.3	F	269.	C
Pre Retro	276720	B	1462 (66.8)	E	-1.3	E	301	G
			1507 (69.2)	C	1.3	F	269	C
Entry	267488	A	1453 (66.4)	E	-1.4	E	301	G
			1498 (68.7)	C	1.4	F	268	C
Landing	266488	A	1449 (66.1)	E	-1.5	E	298	G
			1495 (68.5)	C	1.5	F	258	C
Ferry Take off	282000		( )					
			( )					
Ferry Landing			( )					
			( )					

Notes: *Shows critical payload/expendables configuration indicator from Table D-7 .

1. Reference axis system is defined in Figure D-1.
2. X C.G.'s shown in brackets ( ) are fraction of reference length from nose based on vehicle reference length of 160.3 Ft.
3. Values shown are uncorrelated, i.e., max aft c.g. does not necessarily occur simultaneously with design wt. or other design mass properties. For correlated mass properties refer to Tables D-8 and D-9 using the critical payload/expendables configuration indicator shown.

Table D-2 - Design Mass Properties - Delta Orbiter
Moments and Products of Inertia

Mission Phase	Moment of Inertia 1000 slug ft.sq.			Product of Inertia 1000 slug ft.sq.		
	Roll	Pitch	Yaw	Roll-Pitch	Pitch-Yaw	Yaw-Roll
Booster Separation	2854	43318	43843	-7	-1	2103
Injection	2280	16405	16831	-4	-0	-14
On Orbit	2257	15124	15557	-4	-0	-128
Pre Retro	2280	14114	14814	-4	-1	-46
Entry	2112	13957	14468	-4	-1	-23
Landing	2192	13936	14365	-4	-1	-6
Ferry Takeoff						
Ferry Landing						

Notes: 1. Design moments and products of inertia are based on nominal mission, i.e., payload/expendables configuration A.
2. Moments and products of inertia are with respect to vehicle c.g. and reference axis system shown in Figure D-1.

Note: Design Mass Properties are based on Booster Drawing No. 256-20-001. Detailed analysis is based on Drawing No. 256-20A-001 (see Section 5) with modified tail and nose station changed to 2025.

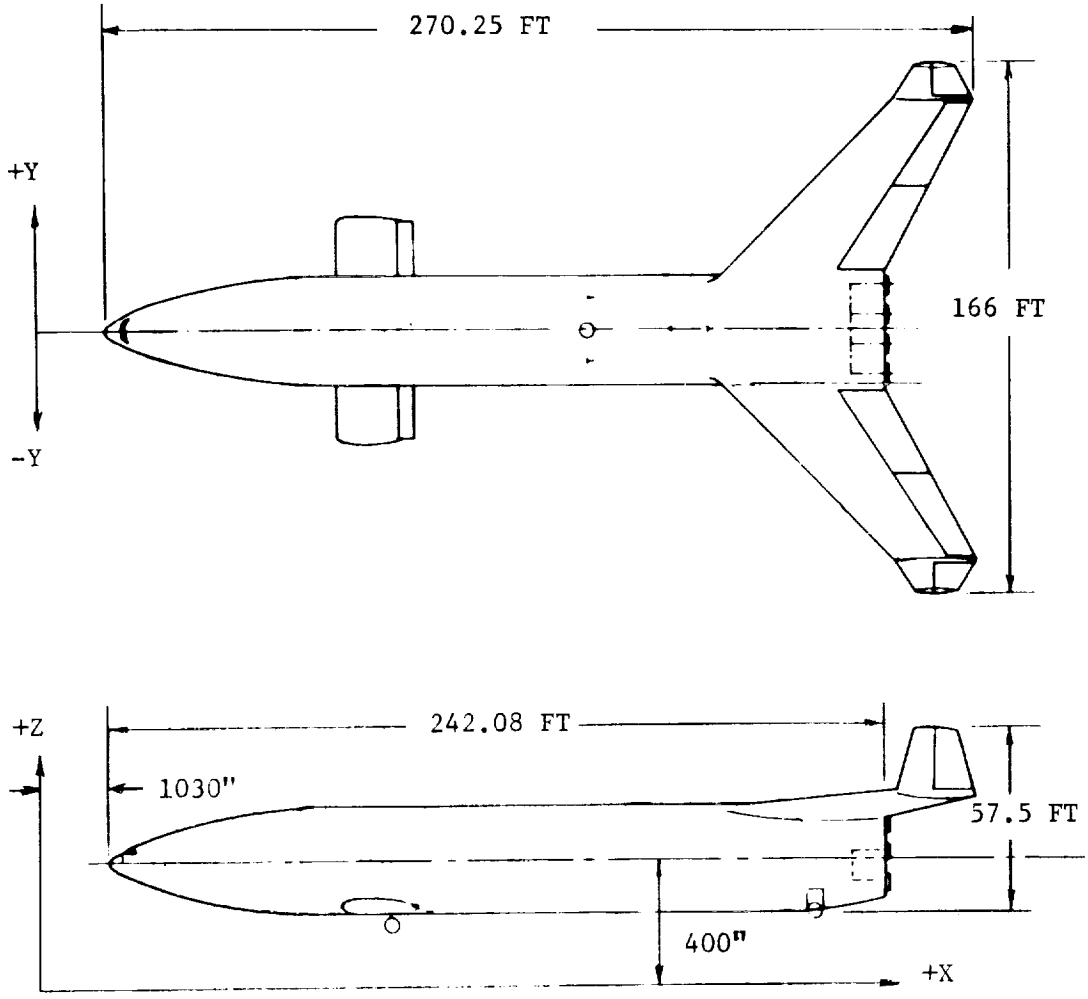


FIGURE D-2 BOOSTER CONFIGURATION/COORDINATE AXES

Table D-3 - Design Mass Properties - Canard Booster

Mission	Weight - Lb.	Center of Gravity (inches) X	Y	Z	Moment of Inertia Roll	Pitch	Yaw
					Product of Inertia Rol-Pit	Pit-Yaw	Yaw-Rol
					1000 slug ft.sq.		
Launch	3779160	2063	0	405	9726	434404	438738
					6	1	11448
Burnout	715160	3001	0	428	9628	118152	122984
					-22	1	7400
Start of Cruise	692187	2991		429	9620	115175	119611
					6	1	7460
End of Cruise	581098	3155	0	437	9133	89496	93705
					17	0	5836
Landing	542098	3105	0	425	8893	84961	89410
					16	-1	4821
Ferry Takeoff	TBD	-	-	-			
Ferry Landing	TBD	-	-	-			

Notes:
1. Design mass properties are based on nominal mission from 15 March Status Report (MP-8A).
2. Vehicle reference length (nose to base) is 2905 inches.
3. Reference axis system is defined in Figure D-2.

Table D-4 - Design Mass Properties - Canard Booster plus Delta Orbiter
Weight and C.G.

Mission Phase	Weight-Lb	*	X C.G.-In Fwd Aft	*	Y C.G.-In Left Right	*	Z C.G.-In Up Down	*
Launch	4638500	A	2065	C	- 0	E	462	G
			2071	D	+ 0	F	456	C
25% Burn	3872500	A	2164	C	- 0	E	474	G
			2169	D	+ 0	F	468	C
50% Burn	3106500	A	2264	C	- 0	E	492	G
			2269	D	+ 0	F	485	C
75% Burn	2340500	A	2373	C	- 0	E	522	G
			2377	D	+ 0	F	513	C
Booster Burnout	1574500	A	2507	C	- 0	E	581	G
			2508	D	+ 0	F	569	C

Notes: * Shows orbiter critical payload/expendables configuration indicator from Table D-7.

1. Reference axis system is same as defined in Figure D-2 for Booster.

2. Values shown are uncorrelated, i.e., max. fwd. c.g. does not necessarily occur simultaneously with design weight or other mass properties shown. For correlated mass properties refer to Table D-9, using the critical payload/expendables configuration indicator.

Table D-5 - Design Mass Properties - Canard Booster Plus Delta Orbiter
Moments and Products of Inertia

Mission Phase	Moment of Inertia 1000 Slug-ft. Sq.			Product of Inertia 1000 Slug-ft. Sq.		
	Roll	Pitch	Yaw	Roll-Pitch	Pitch-Yaw	Yaw-Roll
Launch	26400	491600	482600	- 1	- 3	14580
25% Burn	25600	426100	417900	- 4	- 3	8550
50% Burn	24500	369200	362100	- 6	- 3	2470
75% Burn	22700	308700	303400	- 8	- 4	- 4090
Booster Burnout	19100	238500	236900	- 11	- 5	- 12041

Notes:
1. Design moments and products of inertia are based on nominal mission, i.e., payload/expendables configuration A.
2. Moments and products of inertia are with respect to vehicle nominal c.g..
3. Reference axis system is same as that shown for booster in Figure D-2.

Table D-6 - Ground Rules for Design Mass Properties

Delta Orbiter

1. Definition of Terms

   Design Weight = largest nominal weight at each mission point for any of the 3 design missions, i.e., 40K polar (no ABES), 25K to 55 deg. (with ABES) and 65K easterly (no ABES). Aborts are not considered.

   Design Moments and Products of Inertia = Values that occur simultaneously with design weights.

   Design C.G.'s = Maximum and minimum values obtained from payload, air-breathing engine system, growth/uncertainty and fluid variations described below.

2. Payload Considerations

   a. Nominal payload is 60 inches forward of the center of the payload bay.
   b. Most forward payload c.g. is 120 inches forward of the center of the payload bay.
   c. Most aft payload is at the center of the bay.
   d. Appropriate payloads are considered for each of the three design missions. The nominal payload and payloads to be used in determining c.g. extremes are shown in Tables D-6.1, .2 and .3 for each of these missions. Other payloads resulting from abort or unprescribed operational use of the system are considered overload weight conditions. However, abort conditions with maximum injected payload are considered in determining c.g. extremes.
   e. A minimum payload weight of zero is also used in determining c.g. extremes.

3. Airbreathing Engine Considerations - Airbreathing engines are on or off the vehicle depending upon the mission. When they are removed, a "scar" weight is left in.

4. Uncertainty/Growth Considerations

   a. Weight for U/G is 10% of dry weight items including cruise engines but excluding ascent engines. (Note, this is not the current estimate of U/G.) This value remains constant for all missions.
   b. The center of gravity of the U/G is ±2% of body length from the dry weight c.g. for c.g. dispersion.
   c. Nominal c.g. location for the U/G is at the dry weight c.g. for all missions. (U/G is not a variable as ABES are off-loaded.)

5. Fluid Considerations - Fluid use is described in Tables D-6.1 - D-6.3 for the respective missions.

Canard Booster - Design weights, c.g.'s, moments and products of inertia are based on a nominal booster mission history.

Canard Booster plus Delta Orbiter (Combined Configuration) - Design mass properties for the combined configuration are obtained by combining booster values with the orbiter payload/expendables configurations that determine the orbiter design mass properties.

Table D-6.1 - Design Reference Mission
65000# P.L., NO ABES, 28.5° Incl., 100 NM Circ.

Mission Phase / Condition / System	Injection			On-Orbit			Pre Retro		
	Nom. Wt.	C.G. Envelope Min.	Max.	Nom. Wt.	C.G. Envelope Min.	Max.	Nom. Wt.	C.G. Envelope Min.	Max.
Payload	65000	0	65000	65000	0	65000	40000	0	65000
Ascent	Infl. Losses	P.U. H_2	Infl. Losses	0	0	0	0	0	0
Ascent	1% ΔV Resv.	0% ΔV	2% ΔV Resv.	0	0	0	0	0	0
Orbit Maneuver	1500	1500	1500	840	775	840	660	460	660
Att. Cont. On-Orbit	100%	100%	100%	100%	94%	100%	50%	0%	93%
Att. Cont. Entry	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cruise	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Mission Phase / Condition / System	Entry			Begin Cruise			Landing		
	Nom. Wt.	C.G. Envelope Min.	Max.	Nom. Wt.	C.G. Envelope Min.	Max.	Nom. Wt.	C.G. Envelope Min.	Max.
Payload	40000	0	65000	40000	0	65000	40000	0	65000
Ascent	0%	0	0	0	0	0	0	0	0
Orbit. Maneuver	200	0	200	200	0	200	200	0	200
Att. Cont. On-Orbit	50%	0%	93%	50%	0	93%	50%	0	93%
Att. Contr. Entry	100%	100%	100%	50%	0	67%	50%	0	67%
Cruise	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: Additional residual propellant for each system must be in the vehicle at all mission phases

Table D-6.2 - Polar Mission
40000# P.L., No ABES, 90° INCL, 100 NM CIRC.

Mission Phase / Condition / System	Injection Nom. Wt.	Injection C.G. Envelope Min.	Injection C.G. Envelope Max.	On-Orbit Nom. Wt.	On-Orbit C.G. Envelope Min.	On-Orbit C.G. Envelope Max.	Pre Retro Nom. Wt.	Pre Retro C.G. Envelope Min.	Pre Retro C.G. Envelope Max.
Payload	40000	0	40000	40000	0	40000	40000	0	40000
Ascent	Infl. Losses	P.U. H_2	Infl. Losses	0	0	0	0	0	0
Ascent	1% ΔV Resv.	0% ΔV	2% ΔV Resv.	0	0	0	0	0	0
Orbit Maneuver	1500	1500	1500	840	775	840	660	460	660
Att. Cont. On-Orbit	100%	100%	100%	100%	94%	100%	50%	0%	93%
Att. Cont. Entry	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cruise	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Mission Phase / Condition / System	Entry Nom. Wt.	Entry C.G. Envelope Min.	Entry C.G. Envelope Max.	Begin Cruise Nom. Wt.	Begin Cruise C.G. Envelope Min.	Begin Cruise C.G. Envelope Max.	Landing Nom. Wt.	Landing C.G. Envelope Min.	Landing C.G. Envelope Max.
Payload	40000	0	40000	40000	0	40000	40000	0	40000
Ascent	0	0	0	0	0	0	0	0	0
Orbit. Maneuver	200	0	200fps	200	0	200	200	0	200
Att. Cont. On-Orbit	50%	0%	93%	50%	0%	93%	50%	0	93%
Att. Contr. Entry	100%	100%	100%	50%	0	67%	50%	0	67%
Cruise	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: Additional residual propellant for each system must be in the vehicle at all mission phases

Table D-6.3 Station Resupply Mission
25000# P.L., ABES, 55° Incl., 270 NM

Mission Phase / Condition / System	Injection Nom. Wt.	Injection C.G. Envelope Min.	Injection C.G. Envelope Max.	On-Orbit Nom. Wt.	On-Orbit C.G. Envelope Min.	On-Orbit C.G. Envelope Max.	Pre Retro Nom. Wt.	Pre Retro C.G. Envelope Min.	Pre Retro C.G. Envelope Max.
Payload	25000	0	25000	25000	0	25000	25000	0	25000
Ascent	Infl. Losses	P.U. H_2	Infl. Losses	0	0	0	0	0	0
Ascent	1% ΔV Resv.	0	2% ΔV Resv.	0	0	0	0	0	0
Orbit Maneuver	1500	1500	1500	840	775	840	660	460	660
Att. Cont. On-Orbit	100%	100%	100%	100%	94%	100%	50%	0	93%
Att. Cont. Entry	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cruise	100%	100%	100%	100%	100%	100%	100%	100%	100%

Mission Phase / Condition / System	Entry Nom. Wt.	Entry C.G. Envelope Min.	Entry C.G. Envelope Max.	Begin Cruise Nom. Wt.	Begin Cruise C.G. Envelope Min.	Begin Cruise C.G. Envelope Max.	Landing Nom. Wt.	Landing C.G. Envelope Min.	Landing C.G. Envelope Max.
Payload	25000	0	25000	25000	0	25000	25000	0	25000
Ascent	0	0	0	0	0	0	0	0	0
Orbit. Maneuver	200fps	0	200	200	0	200	200	0	200
Att. Cont. On-Orbit	50%	0	93%	50%	0%	93%	50%	0	93%
Att. Contr. Entry	100%	100%	100%	50%	0%	67%	50%	0	67%
Cruise	100%	100%	100%	100%	100%	100%	67%	0%	67%

Note: Additional residual propellant for each system must be in the vehicle at all mission phases

Table D-7- Summary of Payload/Expendables Configurations
Delta Orbiter

Item	Configuration Designator						
	A	B	C	D	E	F	G
Booster Separation							
Payload Weight-1000 lb.	79653	32508	0	65000	65000	65000	65000
Payload x c.g.-inches	1418	1418	0	1478	1358	1358	1358
Payload Y c.g.-inches	0	0	0	0	-6	6	0
Payload Z c.g.-inches	400	400	0	400	400	400	406
Ascent Propellant Wt.-%	100	100	100	100	100	100	100
Flt. Perf. Reserves-%	100	100	100	100	100	100	100
Inflight Losses-% *	100	100	100	100	100	100	100
OMS Propellant-ft/sec	676	1500	1500	1500	1500	1500	1500
ACS Propellant(on orbit)-%	100	100	100	100	100	100	100
ACS Propellant(entry)-%	100	100	100	100	100	100	100
Cruise/Go Around Propel-%	0	100	100	0	0	0	0
ABES Wt-1000 lb.	0	19	19	0	0	0	0
Growth/Uncert.Wt.-1000 lb	18	18	18	18	18	18	18
Growth/Uncert. x c.g.-in.	1482	1482	1529	1529	1445	1445	1445
Injection							
Payload Weight-1000 lb.	79653	32508	0	65000	65000	65000	65000
Payload x c.g.-inches	1418	1418	0	1478	1358	1358	1358
Payload Y c.g.-inches	0	0	0	0	-6	6	0
Payload Z c.g.-inches	400	400	0	400	400	400	406
Ascent Propellant Wt.-%	0	0	0	0	0	0	0
Flt. Perf. Reserves-%	100	100	0	0	200	200	200
Inflight Losses-% *	100	100	100	100	100	100	100
OMS Propellant-ft/sec	676	1500	1500	1500	1500	1500	1500
ACS Propellant(on orbit)-%	102	100	100	100	100	100	100
ACS Propellant(entry)-%	100	100	100	100	100	100	100
Cruise/Go Around Propel-%	0	100	100	0	0	0	0
ABES Wt-1000 lb.	0	19	19	0	0	0	0
Growth/Uncert.Wt.-1000 lb.	18	18	18	18	18	18	18
Growth/Uncert. x c.g.-in.	1482	1482	1529	1529	1445	1445	1445

Notes: 1. Configuration A is nominal* 28.5° inclination, 65K payload, no ABES mission
2. Configuration B is nominal* 55° inclination, 25K payload, with ABES mission
* from 15 March status (MP-8A)

Table D-7 - Summary of Payload/Expendables Configurations - Cont.
Delta Orbiter

Item	Configuration Designator						
	A	B	C	D	E	F	G
On Orbit							
Payload Weight-1000 lb.	79653	32508	0	65000	65000	65000	65000
Payload x c.g.-inches	1418	1418	0	1478	1358	1358	1358
Payload Y c.g.-inches	0	0	0	0	-6	6	0
Payload Z c.g.-inches	400	400	0	400	400	400	406
Ascent Propellant Wt.-%	0	0	0	0	0	0	0
Flt. Perf. Reserves-%	0	0	0	0	0	0	0
Inflight Losses-% *	100	100	100	100	100	100	100
OMS Propellant-ft/sec	586	840	840	840	775	775	775
ACS Propellant(on orbit)-%	100	100	100	100	94	94	94
ACS Propellant(entry)-%	100	100	100	100	100	100	100
Cruise/Go Around Propel-%	0	100	100	0	0	0	0
ABES Wt-1000 lb.	0	19	19	0	0	0	0
Growth/Uncert.Wt.-1000 lb	18	18	18	18	18	18	18
Growth/Uncert. x c.g.-in.	1482	1482	1529	1529	1445	1445	1445
Pre Retro							
Payload Weight-1000 lb.	40000	25000	0	65000	65000	65000	65000
Payload x c.g.-inches	1418	1418	0	1478	1358	1358	1358
Payload Y c.g.-inches	0	0	0	0	-6	6	0
Payload Z c.g.-inches	400	400	0	400	400	400	406
Ascent Propellant Wt.-%	0	0	0	0	0	0	0
Flt. Perf. Reserves-%	0	0	0	0	0	0	0
Inflight Losses-% *	0	0	0	0	0	0	0
OMS Propellant-ft/sec	450	660	660	660	460	460	460
ACS Propellant(on orbit)-%	50	50	93	93	0	0	0
ACS Propellant(entry)-%	100	100	100	100	100	100	100
Cruise/Go Around Propel-%	0	100	100	0	0	0	0
ABES Wt-1000 lb.	0	19	19	0	0	0	0
Growth/Uncert.Wt.-1000 lb	18	18	18	18	18	18	18
Growth/Uncert. x c.g.-in.	1482	1482	1529	1529	1445	1445	1445

Table D-7 – Summary of Payload/Expendables Configurations - Cont, Delta Orbiter

Item	Configuration Designator						
	A	B	C	D	E	F	G
Entry							
Payload Weight-1000 lb.	40000	25000	0	65000	65000	65000	65000
Payload x c.g.-inches	1418	1418	0	1478	1358	1358	1358
Payload Y c.g.-inches	0	0	0	0	-6	6	0
Payload Z c.g.-inches	400	400	0	400	400	400	406
Ascent Propellant Wt.-%	0	0	0	0	0	0	0
Flt. Perf. Reserves-%	0	0	0	0	0	0	0
Inflight Losses-% *	0	0	0	0	0	0	0
OMS Propellant-ft/sec	200	200	200	200	0	0	0
ACS Propellant(on orbit)-%	50	50	93	93	0	0	0
ACS Propellant(entry)-%	100	100	100	100	100	100	100
Cruise/Go Around Propel-%	0	100	100	0	0	0	0
ABES Wt-1000 lb.	0	19	19	0	0	0	0
Growth/Uncert.Wt.-1000 lb	18	18	18	18	18	18	18
Growth/Uncert. x c.g.-in.	1482	1482	1529	1529	1445	1445	1445
Landing							
Payload Weight-1000 lb.	40000	25000	0	65000	65000	65000	65000
Payload x c.g.-inches	1418	1418	0	1478	1358	1358	1358
Payload Y c.g.-inches	0	0	0	0	-6	6	0
Payload Z c.g.-inches	400	400	0	400	400	400	406
Ascent Propellant Wt.-%	0	0	0	0	0	0	0
Flt. Perf. Reserves-%	0	0	0	0	0	0	0
Inflight Losses-% *	0	0	0	0	0	0	0
OMS Propellant-ft/sec	200	200	200	200	0	0	0
ACS Propellant(on orbit)-%	50	50	93	93	0	0	0
ACS Propellant(entry)-%	50	50	67	67	0	0	0
Cruise/Go Around Propel-%	0	67	67	0	0	0	0
ABES Wt-1000 lb.	0	18	18	0	0	0	0
Growth/Uncert.Wt.-1000 lb	18	18	18	18	18	18	18
Growth/Uncert. x c.g.-in.	1482	1482	1529	1529	1445	1445	1445

* DOES NOT INCLUDE ASCENT PROPELLANTS DUMPED

Table D-8

Correlated Mass Property Mission History Runs
(Delta Orbiter)

	Page
Configuration A - Nominal Easterly Mission	D-18
Configuration B - Nominal Resupply Mission	D-21
Configuration C - No Cargo	D-24
Configuration D - Most Aft	D-27
Configuration E - Most Left, Most Fwd	D-30
Configuration F - Most Right	D-33
Configuration G - Most Up	D-36

Notes: (1) See Table D-7 for configuration descriptions
(2) "Configuration" as used above indicates a different internal arrangement of payload, expendables and growth/uncertainty, not a different external shape.
(3) Subsystem weights for configurations A and B are identical to the nominal values shown in the 15 March Preliminary Detailed Mass Properties Report (MP-8A). Due to the large number of different conditions that had to be considered to define the c.g. extremes and the time required for this analysis, the subsystem weights for the other payload/expendables configurations were frozen prior to finalizing the MP-8A weights and are therefore slightly different.
(4) Numerous payload/expendables configurations were considered in defining the c.g. extremes but only those which set the critical fwd, aft, up, down, left or right limits are shown herein.

DESIGN MASS PROPERTIES CONFIGURATION A

65K EASTERLY MISSION
SEQUENCED MASS PROPERTIES SUMMARY 02/25/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	28311.	1758.	0.	197.	561.	437.	997.
					0.	0.	-9.
TAILS	5790.	2052.	0.	548.	47.	53.	10.
					0.	0.	0.
BODY	62421.	1300.	0.	284.	294.	2887.	2845.
					0.	-0.	53.
THERMAL PROT	32496.	1406.	0.	182.	359.	2408.	2704.
					-0.	0.	-40.
LANDING/DOCK	8963.	1480.	-4.	71.	89.	332.	395.
					-4.	-2.	1.
PROP-ASCENT	25275.	1885.	0.	322.	41.	432.	406.
					0.	0.	14.
PROP-CRUISE	400.	1489.	0.	251.	2.	1.	2.
					0.	0.	-0.
PROP-AUXIL	11805.	1264.	0.	342.	41.	957.	978.
					0.	0.	19.
PRIME POWER	1466.	924.	0.	260.	0.	173.	173.
					0.	0.	4.
ELEC DIST	1364.	830.	0.	345.	9.	98.	104.
					0.	0.	4.
HYDRA DIST	1782.	1820.	0.	290.	15.	15.	15.
					0.	0.	0.
SURF CONTROL	2981.	1800.	0.	300.	28.	130.	136.
					0.	0.	0.
AVIONICS	4365.	1034.	0.	394.	6.	65.	65.
					0.	0.	-3.
ENVIR CONTRL	7088.	1128.	0.	359.	15.	227.	208.
					0.	0.	-9.
PERSNL PROV	210.	840.	0.	450.	0.	0.	0.
					0.	0.	0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	17641.	1482.	0.	254.	171.	986.	1034.
					0.	0.	0.
DRY WEIGHT	212358.	1483.	-0.	266.	2000.	12619.	13167.
					-4.	-1.	89.
PERSONNEL	400.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
LANDED CARGO	40000.	1420.	0.	400.	35.	410.	410.
					0.	0.	0.
RESID FLUIDS	3786.	1387.	0.	279.	5.	257.	258.

DESIGN MASS PROPERTIES CONFIGURATION A

65K EASTERLY MISSION

SEQUENCED MASS PROPERTIES SUMMARY 02/25/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-0.	-0.	-0.
INERT WEIGHT	256544.	1471.	-0.	287.	2175.	13479.	13895.
					-4.	-1.	20.
RESERVE FLDS	9944.	1798.	0.	278.	17.	236.	249.
					0.	0.	-20.
LANDING WT	266488.	1483.	-0.	287.	2192.	13936.	14365.
					-4.	-1.	-6.
CRUISE PROP	0.	0.	0.	0.	0.	0.	0.
					-4.	-1.	-6.
FLIGHT WT	266488.	1485.	-0.	291.	2110.	13907.	14418.
					-4.	-1.	-19.
ENTRY ACS	1000.	1684.	-0.	288.	2.	41.	42.
					-0.	0.	-4.
ENTRY WT	267488.	1486.	-0.	291.	2112.	13957.	14468.
					-4.	-1.	-23.
RETRO PROP	5531.	1741.	-0.	283.	9.	182.	189.
					-0.	0.	-16.
PRE RETRO WT	273019.	1491.	-0.	291.	2121.	14215.	14733.
					-4.	-1.	-41.
ON ORB LOSS	7871.	1621.	-0.	294.	11.	343.	347.
					-0.	0.	-27.
LANDED CARGO	-40000.	1420.	0.	400.	-35.	-410.	-410.
					0.	0.	0.
ASCENT CARGO	79653.	1420.	0.	400.	70.	817.	817.
					0.	0.	0.
ON ORBIT WT	320543.	1486.	-0.	304.	2257.	15124.	15557.
					-4.	-0.	-128.
MANEUV PROP	1991.	1741.	-0.	283.	3.	66.	68.
					-0.	0.	-6.
DUMPED PROP	11583.	820.	0.	228.	5.	100.	105.
					-0.	0.	0.
INJECTION WT	334117.	1464.	-0.	301.	2280.	16405.	16831.

DESIGN MASS PROPERTIES CONFIGURATION A
65K EASTERLY MISSION
SEQUENCED MASS PROPERTIES SUMMARY 02/25/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-4.	-0.	-14.
ASCENT PROP	130950.	997.	0.	228.	102.	1931.	2033.
					0.	0.	0.
75% BURN	465067.	1332.	-0.	281.	2491.	22881.	23299.
					-5.	-1.	683.
ASCENT PROP	130947.	888. @	-0.	228.	88.	1400.	1488.
					0.	-0.	0.
50% BURN	596014.	1235.	-0.	269.	2640.	28702.	29146.
					-6.	-1.	1200.
ASCENT PROP	130949.	763.	0.	228.	64.	1028.	1092.
					-0.	-0.	0.
25% BURN	726963.	1150.	-0.	262.	2743.	34930.	35399.
					-6.	-1.	1650.
ASCENT PROP	130948.	592.	0.	228.	83.	886.	969.
					0.	0.	0.
IGNITION	857911.	1065.	-0.	257.	2853.	43287.	43811.
					-7.	-1.	2101.
STARTUP	1472.	826.	0.	228.	1.	13.	14.
					0.	0.	0.
LAUNCH WT	859383.	1064.	-0.	257.	2854.	43318.	43843.
					-7.	-1.	2103.

DESIGN MASS PROPERTIES CONFIGURATION B
25K, 55° MISSION, W/ABES
SEQUENCED MASS PROPERTIES SUMMARY 02/25/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	28311.	1758.	0.	197.	561.	437.	997.
					0.	0.	-9.
TAILS	5790.	2052.	0.	548.	47.	53.	10.
					0.	0.	0.
BODY	62421.	1300.	0.	284.	294.	2887.	2845.
					0.	-0.	53.
THERMAL PROT	32496.	1406.	0.	182.	359.	2408.	2704.
					-0.	0.	-40.
LANDING/DOCK	8963.	1480.	-4.	71.	89.	332.	395.
					-4.	-2.	1.
PROP-ASCENT	25275.	1885.	0.	322.	41.	432.	406.
					0.	0.	14.
PROP-CRUISE	15246.	1580.	0.	111.	207.	37.	236.
					0.	0.	4.
PROP-AUXIL	11805.	1264.	0.	342.	41.	957.	978.
					0.	0.	19.
PRIME POWER	1466.	924.	0.	260.	0.	173.	173.
					0.	0.	4.
ELEC DIST	1364.	830.	0.	345.	9.	98.	104.
					0.	0.	4.
HYDRA DIST	1782.	1820.	0.	290.	15.	15.	15.
					0.	0.	0.
SURF CONTROL	2981.	1800.	0.	300.	28.	130.	136.
					0.	0.	0.
AVIONICS	4365.	1034.	0.	394.	6.	65.	65.
					0.	0.	-3.
ENVIR CONTRL	7088.	1128.	0.	359.	15.	227.	208.
					0.	0.	-9.
PERSNL PROV	210.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	17641.	1482.	0.	254.	171.	986.	1034.
					0.	0.	0.
DRY WEIGHT	227204.	1489.	-0.	255.	2278.	12758.	13430.
					-4.	-1.	47.
PERSONNEL	400.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
LANDED CARGO	25000.	1420.	0.	400.	22.	256.	256.
					0.	0.	0.
RESID FLUIDS	4010.	1396.	0.	284.	6.	254.	254.

DESIGN MASS PROPERTIES CONFIGURATION B
25K, 55° MISSION, W/ABES
SEQUENCED MASS PROPERTIES SUMMARY 02/25/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-0.	-0.	0.
INERT WEIGHT	256614.	1480.	-0.	270.	2412.	13428.	13996.
					-4.	-1.	-11.
RESERVE FLDS	8405.	1642.	0.	311.	17.	240.	249.
					0.	-0.	-27.
LANDING WT	265019.	1485.	-0.	271.	2432.	13717.	14291.
					-4.	-1.	-26.
CRUISE PROP	1266.	1990.	0.	1209.	-308.	-328.	-15.
					0.	0.	-141.
FLIGHT WT	266285.	1488.	-0.	276.	2363.	13697.	14346.
					-4.	-1.	-39.
ENTRY ACS	1000.	1684.	-0.	1554.	-449.	-379.	12.
					-0.	0.	-36.
ENTRY WT	267285.	1488.	-0.	281.	2265.	13677.	14366.
					-4.	-1.	-21.
RETRO PROP	9435.	1741.	-0.	283.	16.	311.	322.
					-0.	0.	-27.
PRE RETRO WT	276720.	1497.	-0.	281.	2280.	14114.	14814.
					-4.	-1.	-46.
ON ORB LOSS	8933.	1623.	-0.	294.	13.	391.	397.
					-0.	0.	-31.
LANDED CARGO	-25000.	1420.	0.	400.	-22.	-256.	-256.
					0.	0.	0.
ASCENT CARGO	32508.	1420.	0.	400.	29.	333.	333.
					0.	0.	0.
ON ORBIT WT	293161.	1499.	-0.	284.	2323.	14645.	15328.
					-4.	-1.	-90.
MANEUV PROP	13537.	1741.	-0.	283.	23.	447.	462.
					-0.	0.	-39.
DUMPED PROP	11381.	820.	-0.	228.	5.	98.	103.
					0.	-0.	-0.
INJECTION WT	318079.	1485.	-0.	282.	2358.	16486.	17182.

DESIGN MASS PROPERTIES CONFIGURATION B

25K, 55° MISSION, W/ABES
SEQUENCED MASS PROPERTIES SUMMARY 02/25/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-DEET SQ./1000.)		
					-4.	-1.	-38.
ASCENT PROP	130999.	997.	-0.	228.	102.	1932.	2034.
					0.	0.	0.
75% BURN	449078.	1342.	-0.	266.	2518.	23248.	23987.
					-5.	-1.	492.
ASCENT PROP	130999.	888.	0.	228.	88.	1400.	1488.
					-0.	0.	0.
50% BURN	580077.	1240.	-0.	258.	2638.	29204.	29999.
					-6.	-1.	873.
ASCENT PROP	131000.	763.	0.	228.	64.	1028.	1092.
					0.	0.	0.
25% BURN	711077.	1152.	-0.	252.	2722.	35500.	36338.
					-6.	-1.	1200.
ASCENT PROP	130998.	592.	0.	228.	83.	886.	969.
					0.	0.	0.
IGNITION	842075.	1065.	-0.	248.	2819.	43878.	44785.
					-7.	-1.	1523.
STARTUP	1472.	826.	0.	228.	1.	13.	14.
					0.	0.	0.
LAUNCH WT	843547.	1064.	-0.	248.	2820.	43910.	44817.
					-7.	-1.	1525.

DESIGN MASS PROPERTIES CONFIGURATION C

MASS PROPERTIES SUMMARY 02/11/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	30462.	1755.	0.	197.	606.	472.	1078.
					0.	0.	-10.
TAILS	5790.	2052.	0.	548.	47.	53.	10.
					0.	0.	0.
BODY	64790.	1303.	0.	284.	304.	3021.	2979.
					0.	-0.	50.
THERMAL PROT	30961.	1385.	0.	181.	305.	2290.	2532.
					0.	0.	13.
LANDING/DOCK	8963.	1480.	-4.	71.	89.	332.	395.
					-4.	-2.	1.
PROP-ASCENT	25275.	1885.	0.	322.	41.	432.	406.
					0.	0.	14.
PROP-CRUISE	15246.	1580.	0.	111.	207.	37.	236.
					0.	0.	4.
PROP-AUXIL	9987.	1283.	0.	338.	37.	826.	846.
					0.	-0.	14.
PRIME POWER	1719.	821.	0.	258.	0.	190.	190.
					0.	0.	5.
ELEC DIST	1672.	721.	0.	333.	9.	112.	118.
					0.	0.	6.
HYDRA DIST	1782.	1820.	0.	290.	15.	15.	15.
					0.	0.	0.
SURF CONTROL	3496.	1800.	0.	300.	33.	153.	160.
					0.	0.	0.
AVIONICS	4467.	1032.	0.	394.	6.	66.	66.
					0.	0.	-3.
ENVIR CONTRL	7599.	1119.	0.	365.	17.	233.	212.
					0.	0.	-11.
PERSNL PROV	210.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	17502.	1529.	0.	254.	170.	978.	1025.
					0.	0.	0.
DRY WEIGHT	229921.	1490.	-0.	255.	2282.	12934.	13596.
					-4.	-1.	93.
PERSONNEL	400.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
CARGO	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
RESID FLUIDS	3950.	1414.	0.	278.	6.	253.	254.

DESIGN MASS PROPERITES CONFIGURATION C

MASS PROPERTIES SUMMARY 02/11/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-0.	-0.	3.
INERT WEIGHT	234271.	1488.	-0.	256.	2292.	13223.	13881.
					-4.	-1.	86.
RESERVE FLDS	9984.	1649.	0.	307.	20.	306.	316.
					0.	-0.	-32.
LANDING WT	244255.	1495.	-0.	258.	2318.	13588.	14251.
					-4.	-1.	71.
CRUISE PROP	1266.	1990.	0.	1209.	-308.	-328.	-15.
					0.	0.	-141.
FLIGHT WT	245521.	1497.	-0.	263.	2255.	13572.	14303.
					-4.	-1.	57.
ENTRY ACS	925.	1683.	0.	1656.	-477.	-410.	8.
					0.	0.	-35.
ENTRY WT	246446.	1498.	-0.	268.	2164.	13555.	14319.
					-4.	-1.	74.
RETRO PROP	9291.	1741.	-0.	283.	16.	306.	317.
					-0.	0.	-27.
PRE RETRO WT	255737.	1507.	-0.	269.	2180.	13976.	14750.
					-4.	-1.	54.
ON ORB LOSS	7921.	1623.	-0.	294.	12.	348.	353.
					-0.	0.	-28.
ON ORBIT WT	263658.	1510.	-0.	269.	2193.	14348.	15126.
					-4.	-1.	31.
MANEUV PROP	13329.	1741.	0.	283.	22.	440.	455.
					0.	0.	-38.
DUMPED PROP	4964.	816.	0.	228.	1.	41.	42.
					0.	0.	-0.
INJECTION WT	281951.	1509.	-0.	269.	2219.	15500.	16293.
					-4.	-1.	33.
ASCENT PROP	137332.	989.	-0.	228.	105.	2028.	2133.
					-0.	0.	0.

DESIGN MASS PROPERTIES CONFIGURATION C

MASS PROPERTIES SUMMARY 02/11/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
75% BURN	419283.	1339.	-0.	256.	2358.	22955.	23819.
					-5.	-1.	461.
ASCENT PROP	131000.	888.	0.	228.	88.	1400.	1488.
					0.	0.	0.
50% BURN	550283.	1231.	-0.	249.	2463.	28750.	29685.
					-6.	-1.	731.
ASCENT PROP	131000.	763.	0.	228.	64.	1028.	1092.
					0.	0.	0.
25% BURN	681283.	1141.	-0.	245.	2537.	34800.	35789.
					-6.	-1.	958.
ASCENT PROP	131000.	592.	0.	228.	83.	886.	969.
					0.	0.	0.
STARTUP	1417.	835.	-0.	228.	1.	14.	15.
					-0.	-0.	0.
LAUNCH WT	813700.	1052.	-0.	242.	2627.	42869.	43934.
					-7.	-1.	1181.

DESIGN MASS PROPERITES CONFIGURATION D
MASS PROPERTIES SUMMARY 16:05 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	30462.	1755.	0.	197.	606.	472.	1078.
					0.	0.	-10.
TAILS	5790.	2052.	0.	548.	47.	53.	10.
					0.	0.	0.
BODY	64790.	1303.	0.	284.	304.	3021.	2979.
					0.	-0.	50.
THERMAL PROT	30961.	1385.	0.	181.	305.	2290.	2532.
					0.	0.	13.
LANDING/DOCK	8963.	1480.	-4.	71.	89.	332.	395.
					-4.	-2.	1.
PROP-ASCENT	25275.	1885.	0.	322.	41.	432.	406.
					0.	0.	14.
PROP-CRUISE	400.	1489.	0.	251.	2.	1.	2.
					0.	0.	-0.
PROP-AUXIL	9987.	1283.	0.	338.	37.	826.	846.
					0.	-0.	14.
PRIME POWER	1719.	821.	0.	258.	0.	190.	190.
					0.	0.	5.
ELEC DIST	1672.	721.	0.	333.	9.	112.	118.
					0.	0.	6.
HYDRA DIST	1782.	1820.	0.	290.	15.	15.	15.
					0.	0.	0.
SURF CONTROL	3496.	1800.	0.	300.	33.	153.	160.
					0.	0.	0.
AVIONICS	4467.	1032.	0.	394.	6.	66.	66.
					0.	0.	-3.
ENVIR CONTRL	7599.	1119.	0.	365.	17.	233.	212.
					0.	0.	-11.
PERSNL PROV	210.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	17502.	1529.	0.	254.	170.	978.	1025.
					0.	0.	0.
DRY WEIGHT	215075.	1484.	-0.	265.	2005.	12796.	13334.
					-4.	-1.	134.
PERSONNEL	400.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
CARGO	65000.	1478.	0.	400.	57.	667.	667.
					0.	0.	0.
RESID FLUIDS	3750.	1412.	0.	274.	5.	253.	254.

DESIGN MASS PROPERTIES CONFIGURATION D
MASS PROPERTIES SUMMARY 16:05 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y (INCH)	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-0.	-0.	3.
INERT WEIGHT	284225.	1481.	-0.	297.	2265.	13944.	14285.
					-4.	-0.	122.
RESERVE FLDS	7450.	1716.	0.	286.	12.	275.	283.
					0.	-0.	-23.
LANDING WT	291675.	1487.	-0.	296.	2277.	14306.	14654.
					-4.	-0.	96.
CRUISE PROP	0.	0.	0.	0.	0.	0.	0.
					-4.	-0.	96.
FLIGHT WT	291675.	1489.	-0.	300.	2192.	14271.	14705.
					-4.	-0.	80.
ENTRY ACS	925.	1683.	0.	288.	2.	38.	39.
					0.	0.	-3.
ENTRY WT	292600.	1490.	-0.	300.	2193.	14317.	14752.
					-4.	-0.	76.
RETRO PROP	9291.	1741.	-0.	283.	16.	306.	317.
					-0.	0.	-27.
PRE RETRO WT	301891.	1498.	-0.	299.	2209.	14746.	15192.
					-4.	-0.	41.
ON ORB LOSS	7921.	1623.	-0.	294.	12.	348.	353.
					-0.	0.	-28.
ON ORBIT WT	309812.	1501.	-0.	299.	2221.	15121.	15571.
					-4.	-0.	12.
MANEUV PROP	22648.	1741.	0.	283.	38.	747.	774.
					0.	0.	-65.
DUMPED PROP	4964.	816.	0.	228.	1.	41.	42.
					0.	0.	-0.
INJECTION WT	337424.	1507.	-0.	297.	2267.	16697.	17169.
					-4.	-0.	-18.
ASCENT PROP	137332.	989.	-0.	228.	105.	2028.	2133.
					-0.	0.	0.

DESIGN MASS PROPERTIES CONFIGURATION D

MASS PROPERTIES SUMMARY 16:05 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
75% BURN	474756.	1357.	-0.	277.	2473.	24479.	24955.
					-5.	-1.	736.
ASCENT PROP	131000.	888.	0.	228.	88.	1400.	1488.
					0.	0.	0.
50% BURN	605756.	1256.	-0.	266.	2614.	30811.	31322.
					-6.	-1.	1246.
ASCENT PROP	131000.	763.	0.	228.	64.	1028.	1092.
					0.	0.	0.
25% BURN	736756.	1168.	-0.	260.	2712.	37517.	38058.
					-6.	-1.	1687.
ASCENT PROP	131000.	592.	0.	228.	83.	886.	969.
					0.	0.	0.
STARTUP	1417.	835.	-0.	228.	1.	14.	15.
					-0.	-0.	0.
LAUNCH WT	869173.	1081.	-0.	255.	2820.	46416.	47015.
					-7.	-1.	2126.

DESIGN MASS PROPERTIES CONFIGURATION E
MASS PROPERTIES SUMMARY 03/02/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
WING	30462.	1755.	0.	197.	606.	472.	1078.
					0.	0.	-10.
TAILS	5790.	2052.	0.	549.	47.	53.	10.
					0.	0.	0.
BODY	64790.	1303.	0.	284.	304.	3021.	2979.
					0.	-0.	50.
THERMAL PROT	30961.	1385.	0.	181.	305.	2290.	2532.
					0.	0.	13.
LANDING/DOCK	8963.	1480.	-4.	71.	89.	332.	395.
					-4.	-2.	1.
PROP-ASCENT	25275.	1885.	0.	322.	41.	432.	406.
					0.	0.	14.
PROP-CRUISE	400.	1489.	0.	251.	2.	1.	2.
					0.	0.	-0.
PROP-AUXIL	9987.	1283.	0.	338.	37.	826.	846.
					0.	-0.	14.
PRIME POWER	1719.	821.	0.	258.	0.	190.	190.
					0.	0.	5.
ELEC DIST	1672.	721.	0.	333.	9.	112.	118.
					0.	0.	6.
HYDRA DIST	1782.	1820.	0.	290.	15.	15.	15.
					0.	0.	0.
SURF CONTROL	3496.	1800.	0.	300.	33.	153.	160.
					0.	0.	0.
AVIONICS	4467.	1032.	0.	394.	6.	66.	66.
					0.	0.	-3.
ENVIR CONTRL	7599.	1119.	0.	365.	17.	233.	212.
					0.	0.	-11.
PERSNL PROV	210.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GROWTH/UNCER	17502.	1445.	0.	254.	170.	978.	1025.
					0.	0.	0.
DRY WEIGHT	215075.	1477.	-0.	265.	2005.	12792.	13330.
					-4.	-1.	138.
PERSONNEL	400.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
CARGO	65000.	1358.	-6.	400.	57.	667.	667.
					0.	0.	0.
RESID FLUIDS	3750.	1412.	0.	274.	5.	253.	254.

DESIGN MASS PROPERTIES CONFIGURATION E

MASS PROPERTIES SUMMARY 03/02/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-0.	-0.	3.
INERT WEIGHT	284225.	1448.	-1.	297.	2265.	14087.	14429.
					3.	-9.	-39.
RESERVE FLDS	314.	1740.	0.	284.	0.	13.	13.
					0.	0.	0.
LANDING WT	284539.	1449.	-1.	297.	2266.	14105.	14446.
					3.	-9.	-39.
CRUISE PROP	0.	0.	0.	0.	0.	0.	0.
					3.	-9.	-39.
FLIGHT WT	284539.	1451.	-1.	300.	2180.	14082.	14509.
					4.	-9.	-45.
ENTRY ACS	2775.	1684.	0.	288.	5.	114.	116.
					0.	-0.	-10.
ENTRY WT	287314.	1453.	-1.	300.	2185.	14228.	14658.
					4.	-9.	-57.
RETRO PROP	9291.	1741.	-0.	283.	16.	306.	317.
					-0.	0.	-27.
PRE RETRO WT	296605.	1462.	-1.	300.	2201.	14696.	15136.
					5.	-9.	-93.
ON ORB LOSS	11836.	1656.	-0.	291.	18.	493.	503.
					-0.	0.	-40.
ON ORBIT WT	308441.	1470.	-1.	299.	2219.	15282.	15731.
					5.	-9.	-139.
MANEUV PROP	24019.	1740.	0.	283.	40.	794.	822.
					0.	0.	-69.
DUMPED PROP	17628.	823.	-0.	228.	9.	157.	166.
					-0.	0.	-0.
INJECTION WT	350088.	1456.	-1.	295.	2287.	18207.	18673.
					4.	-9.	-59.
ASCENT PROP	124668.	1005.	0.	228.	98.	1832.	1930.
					0.	0.	0.

DESIGN MASS PROPERTIES CONFIGURATION E

MASS PROPERTIES SUMMARY 03/02/71

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
75% BURN	474756.	1338.	-1.	277.	2473.	24152.	24629.
					-7.	-11.	536.
ASCENT PROP	131000.	888.	0.	228.	88.	1400.	1488.
					0.	0.	0.
50% BURN	605756.	1240.	-1.	266.	2614.	30087.	30598.
					-16.	-12.	1026.
ASCENT PROP	131000.	763.	0.	228.	64.	1028.	1092.
					0.	0.	0.
25% BURN	736756.	1155.	-1.	260.	2713.	36448.	36989.
					-23.	-13.	1453.
ASCENT PROP	131000.	592.	0.	228.	83.	896.	969.
					0.	0.	0.
STARTUP	1417.	835.	-0.	228.	1.	14.	15.
					-0.	-0.	0.
LAUNCH WT	869173.	1070.	-0.	255.	2820.	45001.	45601.
					-31.	-13.	1992.

DESIGN MASS PROPERTIES CONFIGURATION F

MASS PROPERTIES SUMMARY 15:49 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
75% BURN	474756.	1338.	1.	277.	2473.	24152.	24629.
					-3.	10.	536.
ASCENT PROP	131000.	888.	0.	228.	88.	1400.	1488.
					0.	0.	0.
50% BURN	605756.	1240.	1.	266.	2615.	30087.	30598.
					4.	11.	1026.
ASCENT PROP	131000.	763.	0.	228.	64.	1028.	1092.
					0.	0.	0.
25% BURN	736756.	1155.	0.	260.	2713.	36448.	36989.
					11.	11.	1453.
ASCENT PROP	131000.	592.	0.	228.	83.	886.	969.
					0.	0.	0.
STARTUP	1417.	835.	-0.	228.	1.	14.	15.
					-0.	-0.	0.
LAUNCH WT	869173.	1070.	0.	255.	2820.	45001.	45601.
					17.	11.	1882.

DESIGN MASS PROPERTIES CONFIGURATION G

MASS PROPERTIES SUMMARY 15:50 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL (SLUG-FEET SQ./1000.)
WING	30462.	1755.	0.	197.	606.	472.	1078.
					0.	0.	-10.
TAILS	5790.	2052.	0.	548.	47.	53.	10.
					0.	0.	0.
BODY	64790.	1303.	0.	284.	304.	3021.	2972.
					0.	-0.	50.
THERMAL PROT	30961.	1385.	0.	181.	305.	2290.	2532.
					0.	0.	13.
LANDING/DECK	8963.	1480.	-4.	71.	89.	332.	395.
					-4.	-2.	1.
PROP-ASCENT	25275.	1885.	0.	322.	41.	432.	406.
					0.	0.	14.
PROP-CRUISE	400.	1489.	0.	251.	2.	1.	2.
					0.	0.	-0.
PROP-AUXIL	9987.	1283.	0.	338.	37.	826.	846.
					0.	-0.	14.
PRIME POWER	1719.	821.	0.	258.	0.	190.	190.
					0.	0.	5.
ELEC DIST	1672.	721.	0.	333.	9.	112.	118.
					0.	0.	6.
HYDRA DIST	1782.	1820.	0.	290.	15.	15.	15.
					0.	0.	0.
SURF CONTROL	3496.	1800.	0.	300.	33.	153.	160.
					0.	0.	0.
AVIONICS	4467.	1032.	0.	394.	6.	66.	66.
					0.	0.	-3.
ENVIR CONTRL	7599.	1119.	0.	365.	17.	233.	212.
					0.	0.	-11.
PERSNL PROV	210.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
ABORT	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
BALLAST	0.	0.	0.	0.	0.	0.	0.
					0.	0.	0.
GRWTH/UNCER	17502.	1445.	0.	254.	170.	978.	1025.
					0.	0.	0.
DRY WEIGHT	215075.	1477.	-0.	265.	2005.	12792.	13330.
					-4.	-1.	138.
PERSONNEL	400.	940.	0.	450.	0.	0.	0.
					0.	0.	0.
CARGO	65000.	1358.	0.	406.	57.	667.	667.
					0.	0.	0.
RESID FLUIDS	3750.	1412.	0.	274.	5.	253.	254.

DESIGN MASS PROPERTIES CONFIGURATION G

MASS PROPERTIES SUMMARY 15:50 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y (INCH)	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
					-0.	-0.	3.
INERT WEIGHT	284225.	1448.	-0.	298.	2283.	14105.	14428.
					-4.	-0.	-46.
RESERVE FLDS	314.	1740.	0.	284.	0.	13.	13.
					0.	0.	0.
LANDING WT	284539.	1449.	-0.	298.	2283.	14123.	14446.
					-4.	-0.	-46.
CRUISE PROP	0.	0.	0.	0.	0.	0.	0.
					-4.	-0.	-46.
FLIGHT WT	284539.	1451.	-0.	302.	2197.	14099.	14509.
					-4.	-0.	-53.
ENTRY ACS	2775.	1684.	0.	288.	5.	114.	116.
					0.	-0.	-10.
ENTRY WT	287314.	1453.	-0.	301.	2201.	14245.	14657.
					-4.	-0.	-65.
RETRO PROP	9291.	1741.	-0.	289.	16.	306.	317.
					-0.	0.	-27.
PRE RETRO WT	296605.	1462.	-0.	301.	2218.	14713.	15135.
					-4.	-0.	-102.
RN PRP LOSS	11836.	1656.	-0.	291.	18.	493.	503.
					-0.	0.	-40.
RN ORBIT WT	308441.	1470.	-0.	301.	2236.	15299.	15730.
					-4.	-0.	-147.
MANEUV PROP	24013.	1740.	0.	283.	40.	794.	822.
					0.	0.	-69.
DUMPED PROP	17628.	823.	-0.	228.	9.	157.	166.
					-0.	0.	-0.
INJECTION WT	350088.	1456.	-0.	296.	2305.	18225.	18673.
					-4.	-0.	-67.
ASCENT PROP	124668.	1005.	0.	228.	98.	1832.	1930.
					0.	0.	0.

DESIGN MASS PROPERTIES CONFIGURATION G

MASS PROPERTIES SUMMARY 15:50 FEB 1

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X	Y	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
75% BURN	474776.	1335.	-0.	278.	2494.	24173.	24629.
					-5.	-1.	538.
ASCENT PROP	131000.	888.	0.	228.	88.	1400.	1488.
					0.	0.	0.
50% BURN	605756.	1240.	-0.	267.	2637.	30109.	30598.
					-6.	-1.	1035.
ASCENT PROP	131000.	763.	0.	228.	64.	1028.	1092.
					0.	0.	0.
25% BURN	736756.	1155.	-0.	260.	2736.	36472.	36988.
					-6.	-1.	1470.
ASCENT PROP	131000.	598.	0.	228.	83.	886.	969.
					0.	0.	0.
STARTUP	1417.	835.	-0.	228.	1.	14.	15.
					-0.	-0.	0.
LAUNCH AT	868173.	1070.	-0.	255.	2845.	45026.	45601.
					-7.	-1.	1907.

Table D-9

Correlated Mass Property Mission History Runs
(Canard Booster Plus Delta Orbiter)

	Page
Configuration A - Nominal Easterly Mission	D-40
Configuration B - Nominal Resupply Mission	D-41
Configuration C - No Cargo	D-42
Configuration D - Most Aft	D-43
Configuration E - Most Left, Most Fwd	D-44
Configuration F - Most Right	D-45
Configuration G - Most Up	D-46

Note: See Table D-7 for configuration descriptions.

DESIGN MASS PROPERTIES CONFIGURATION A
SEQUENCED MASS PROPERTIES SUMMARY
NOMINAL 65K EASTERLY MISSION
(CANARD BOOSTER & DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	859383.	2086.	-0.	708.	2853.	43276.	43813.
					-7.	-1.	2103.
BOOSTER BO	715160.	3001.	0.	428.	9628.	118161.	122594.
					-22.	1.	7402.
BURN OUT WT	1574543.	2501.	0.	581.	10068.	238501.	236884.
					-11.	-5.	-12041.
75% BURN	2340544.	2372.	0.	521.	22695.	308671.	303427.
					-8.	-4.	-4089.
50% BURN	3106544.	2265.	0.	492.	24534.	369176.	362093.
					-6.	-3.	2474.
25% BURN	3872544.	2166.	0.	473.	25645.	426072.	417878.
					-4.	-3.	8553.
LAUNCH WT	4638543.	2068.	0.	461.	26389.	491569.	482631.
					-1.	-3.	14583.

DESIGN MASS PROPERTIES CONFIGURATION B
SEQUENCED MASS PROPERTIES SUMMARY

NOMINAL 25K, 55° MISSION WITH ABES
(CANARD BOOSTER & DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	843547.	2086.	-0.	699.	2800.	43892.	44791.
					-7.	-1.	1510.
BOOSTER BO	717200.	2998.	0.	428.	9629.	118582.	123014.
					-21.	1.	7427.
BURN OUT WT	1560747.	2505.	0.	574.	18582.	238192.	237370.
					-11.	-5.	-11752.
75% BURN	2326748.	2374.	0.	517.	21955.	308373.	304179.
					-8.	-4.	-4026.
50% BURN	3092748.	2266.	0.	488.	23657.	368884.	362987.
					-6.	-3.	2308.
25% BURN	3858748.	2166.	0.	471.	24683.	425761.	418839.
					-4.	-3.	8155.
LAUNCH WT	4624747.	2068.	0.	459.	25369.	491215.	483606.
					-1.	-3.	13948.

DESIGN MASS PROPERTIES CONFIGURATION C

SEQUENCED MASS PROPERTIES SUMMARY 03/06/71

(CANARD BOOSTER + DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	813700.	2074.	-0.	693.	2627.	42860.	43906.
					-7.	-1.	1183.
BOOSTER BO	715160.	3001.	0.	428.	9628.	118161.	122594.
					-22.	1.	7402.
BURN OUT WT	1528860.	2507.	0.	569.	18038.	237345.	237041.
					-11.	-5.	-11613.
75% BURN	2294861.	2373.	0.	513.	21191.	307403.	303946.
					-8.	-4.	-4123.
50% BURN	3060861.	2264.	0.	485.	22766.	367684.	362652.
					-6.	-3.	1957.
25% BURN	3826861.	2164.	0.	468.	23711.	424242.	418266.
					-4.	-3.	7547.
LAUNCH WT	4592860.	2065.	0.	456.	24340.	480270.	482664.
					-1.	-3.	13072.

DESIGN MASS PROPERTIES CONFIGURATION D

SEQUENCED MASS PROPERTIES SUMMARY 03/06/71

(CANARD BOOSTER + DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY (INCH) X	Y	Z	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	869173.	2103.	-0.	706.	2820.	46413.	47012.
					-7.	-1.	2127.
BOOSTER BO	715160.	3001.	0.	428.	9628.	118161.	122594.
					-22.	1.	7402.
BURN OUT WT	1584333.	2508.	0.	580.	18984.	239340.	237836.
					-11.	-5.	-11589.
75% BURN	2350334.	2377.	0.	522.	22611.	310144.	305013.
					-8.	-4.	-3494.
50% BURN	3116334.	2269.	0.	492.	24455.	371233.	364258.
					-6.	-3.	3160.
25% BURN	3882334.	2169.	0.	474.	25571.	428711.	420620.
					-4.	-3.	9304.
LAUNCH WT	4648333.	2071.	0.	461.	26319.	494828.	485989.
					-1.	-3.	15390.

DESIGN MASS PROPERTIES CONFIGURATION E

SEQUENCED MASS PROPERTIES SUMMARY 03/06/71

(CANARD BOOSTER + DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	869173.	2092.	-0.	706.	2820.	45005.	45597.
					-31.	-13.	1883.
BOOSTER 30	715160.	3001.	0.	428.	9628.	118161.	122594.
					-22.	1.	7402.
BURN OUT WT	1584333.	2502.	-0.	580.	18984.	239616.	238105.
					-1.	-28.	-12091.
75% BURN	2350334.	2373.	-0.	522.	22611.	309885.	304747.
					-9.	-32.	-4118.
50% BURN	3116334.	2266.	-0.	492.	24455.	370531.	363549.
					-16.	-34.	2475.
25% BURN	3882334.	2167.	-0.	474.	25571.	427594.	419496.
					-22.	-35.	8582.
LAUNCH WT	4648333.	2069.	-0.	461.	26329.	493306.	484459.
					-28.	-36.	14643.

DESIGN MASS PROPERTIES CONFIGURATION F

SEQUENCED MASS PROPERTIES SUMMARY 03/06/71

(CANARD BOOSTER + DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	869173.	2092.	0.	706.	2820.	45005.	45597.
					17.	11.	1883.
BOOSTER BO	715160.	3001.	0.	428.	9628.	118161.	122594.
					-22.	1.	7402.
BURN OUT WT	1584333.	2502.	0.	580.	18984.	239615.	238104.
					-22.	17.	-12092.
75% BURN	2350334.	2373.	0.	522.	22611.	309885.	304747.
					-8.	24.	-4118.
50% BURN	3116334.	2266.	0.	492.	24455.	370530.	363549.
					4.	27.	2474.
25% BURN	3882334.	2167.	0.	474.	25571.	427595.	419497.
					14.	29.	8581.
LAUNCH WT	4648333.	2069.	0.	461.	26319.	493306.	484460.
					25.	30.	14642.

DESIGN MASS PROPERTIES CONFIGURATION G

SEQUENCED MASS PROPERTIES SUMMARY 03/06/71

(CANARD BOOSTER + DELTA ORBITER)

DESCRIPTION	CURRENT WEIGHT (LB)	CENTER OF GRAVITY X (INCH)	Y (INCH)	Z (INCH)	MOMENT OF INERTIA ROLL	PITCH	YAW
					PRODUCT OF INERTIA ROL-PIT	PIT-YAW	YAW-ROL
					(SLUG-FEET SQ./1000.)		
ORBITER SEP	869173.	2092.	-0.	706.	2839.	45042.	45597.
					-7.	-1.	1907.
BOOSTER BO	715160.	3001.	0.	428.	9628.	118161.	122594.
					-22.	1.	7402.
BURN OUT WT	1584332.	2502.	0.	581.	19027.	239675.	238103.
					-11.	-5.	-12107.
75% BURN	2350333.	2373.	0.	522.	22665.	309957.	304746.
					-8.	-4.	-4120.
50% BURN	3116333.	2266.	0.	492.	24514.	370608.	363548.
					-6.	-3.	2482.
25% BURN	3882333.	2167.	0.	474.	25634.	427677.	419497.
					-4.	-3.	8598.
LAUNCH WT	4648332.	2069.	0.	462.	26385.	493391.	484460.
					-1.	-3.	14668.